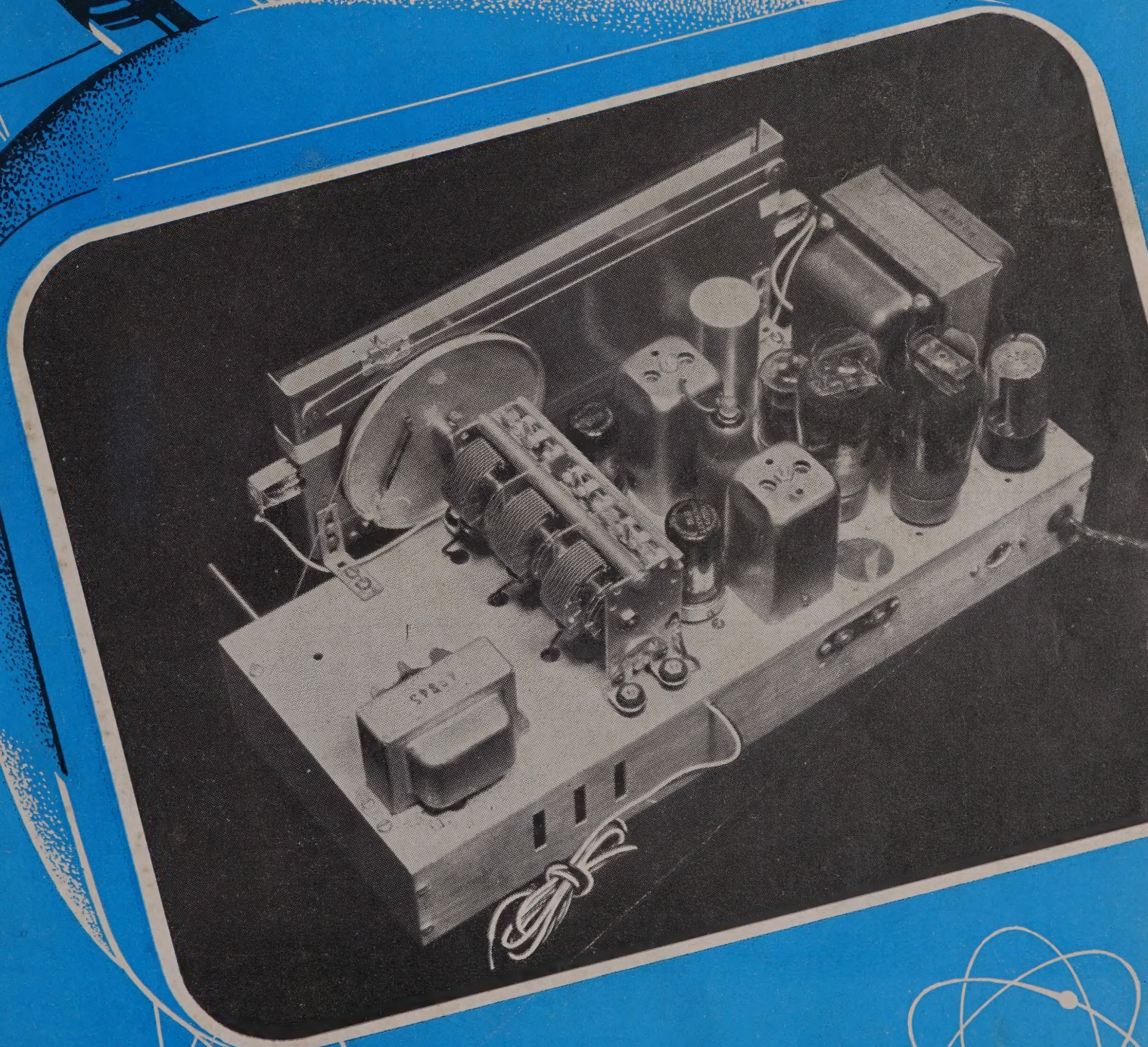
RADIO and ELECTRONICS

TELEVISION - COMMUNICATIONS - SERVICE - SOUND



FEBRUARY 1st, 1954 VOL. 8, NO. 12

If you can't get 85's the answer's surely—

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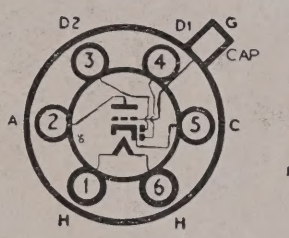
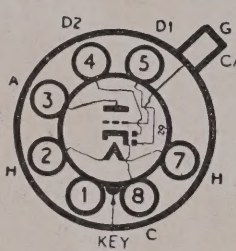
TYPE 85 is a low mu double diode triode, normally used in conjunction with transformer coupling. It may be successfully replaced by type 6R7G.

With fixed bias operation or with transformer coupling, it is necessary to reduce the bias to about half of its previous value when type 6R7G is substituted.

In a self bias resistance coupled stage, however, only a change of socket is required.



TYPE 85



TYPE 6R7G

CHARACTERISTICS	85	6R7G	
Heater Voltage	6.3	6.3	volts
Heater Current	0.3	0.3	amp.
Anode Voltage	250	250	volts
Anode Current	9.0	9.5	mA
Grid Bias	−20	−9	volts
Amp. Factor	8.3	16	—
Impedance	7500	8500	ohms

VALVE TYPE		CHANGE SOCKET		CHANGE CONNECTIONS		OTHER WORK NECESSARY	PERFORMANCE CHANGE
FROM	TO	FROM	TO	FROM OLD SOCKET	TO NEW SOCKET		
85	6R7G	U.X. 6 Pin	International Octal.	Pin No. 1 " " 2 " " 3 " " 4 " " 5 " " 6	Pin No. 2 " " 3 " " 4 " " 5 " " 8 " " 7	For Fixed Bias or Transformer Coupling, decrease bias to half of its previous value.	Increased gain.

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Radio and Electronics

VOL. 8, No. 12 1st February, 1954

OUR COVER:

This month's cover picture shows a view of the seven-valve bandspread radio-gram whose circuit is discussed on page 4 of this issue.

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Fidelity and Superlatives

It has been apparent for some time that there has been a vastly increased public interest in high-quality reproduction of music, not only in this country, but in Britain and America as well, and it is interesting to speculate on the probable causes of this phenomenon, and on other questions which arise in connection with it.

Fundamentally, of course, it is bound up with the immense interest in music itself. This interest has never been greater than it is today; those who first observed its beginnings during the last war posed the question that it might be due in some way to the unnatural conditions obtaining in war-time, and wondered whether it would continue after the war was over. We now know the answer to this last question, and it is that public interest in music and its performance has heightened since the war, rather than declined. It is only natural, therefore, that it should be accompanied by a heightening of interest in the electrical reproduction of music from gramophone records, since this is merely a part of the larger phenomenon. There are, however, other contributory reasons.

In the first place, since the war, there have been great advances in technique. These have affected every link in the chain of reproduction, from records themselves, through pick-ups and amplifiers, up to the loudspeaker. As we have remarked before on these pages, the average enthusiast can now afford equipment the quality of which, in terms of results, would have been found only in laboratories and broadcast studios before 1940. This is perhaps the most potent technical reason for the astounding growth in the numbers of what the Americans call "audiophiles."

These days, in short, "high-fidelity" reproduction can, and often does, merit its title quite fully. Another reason for its popularity is to be found in the fact that when really good audio equipment begins to be used by recorded-music enthusiasts it automatically increases the demand for itself.

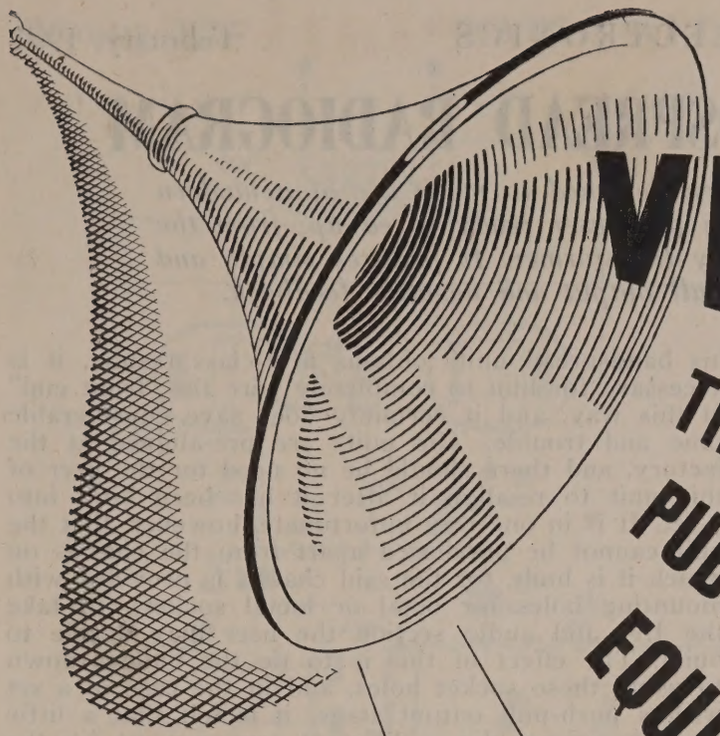
A third reason is to be found in the fact that, at long last, people are beginning to realize that the pleasantness of the sounds that issue from a radio-gramophone does not necessarily bear any relationship to the cost or impressive appearance of the cabinet in which it is housed. This, again, is being brought about to no small extent by the existence in people's homes of really good reproducing equipment, which may or may not have been professionally built, but which is able to show up in no uncertain manner the shortcomings of many commercial radio-gramophone combinations.

So far, the picture looks quite a rosy one, both for the consumer and the seller of high-fidelity equipment, but we are sure that a word of caution would not go amiss at this stage. A recent issue of a well-known American magazine contains an editorial which shows that in the United States, where high-quality audio equipment has become very big business, the term "high-fidelity" is likely to fall into disrepute, and with it the whole business, if certain disturbing trends are not suppressed. It appears that there the potential fruits of selling "high-fidelity" equipment are so great that numerous firms have sprung up who are attempting to cash in on the market with mediocre equipment for which extravagant claims are made. In other words, the whole thing is in danger of becoming a racket. This danger is always present, even where all the equipment offered for sale is of good quality, but where inferior gear is sold under claims that are nothing short of fraudulent, it is very great indeed.

Luckily, we and our compatriots in Great Britain are much less likely to indulge in such flights of commercialism than our friends in America seem to be, and we would not suggest that the same danger exists here. It is as well to take note of it, however, because some of the criticisms levelled in so-called technical advertising in America can also be aimed at some similar advertising in British journals. For instance, it is common enough everywhere to see such statements as "Frequency response from 30 to 12,000 cycles." Now, this sort of statement impresses those who know only a little about the relevant technicalities, but means absolutely nothing. Sometimes, no doubt, such a statement in an advertisement is due to the fact that the advertising copy is not, in general, written by an engineer, and there is no intention to mislead. It is just as possible, however, for it to be made intentionally with the object of leading the reader to believe that the response is flat within the stated limits, whereas, in fact, it may only be "flat" within plus and minus six decibels, or even more! The fact is, of course, that any amplifier can be said to have a response between these or any other limits, as long as the drop below the reference level is not stated. In one case, measurements might show the amplifier to be flat to within plus and minus 1 db., while another could be down by 20 db. or more at the stated frequencies. In the latter case, the response could hardly be said to be useful, but no one could deny that there was "response"!

If equipment that really earns the appellation of "high-fidelity" is advertised as such, then no harm can be done. It is only by "plugging" of inferior gear that the public can be put off from buying high-quality reproduction. But we all have a responsibility in the matter—manufacturers, professionals, and amateurs alike. Perfect reproduction we know to be an unattainable objective, but it is only by admitting the imperfections of our existing equipment, even when our business is selling it, that overall progress can continue.

As a responsible journal, we have always attempted to state fairly the advantages and disadvantages of the equipment designed and built in our own laboratory, and have tried to avoid making claims that cannot be substantiated. From what we know of our advertisers, too, we are sure that they are not guilty of the kind of misleading advertising complained of by our contemporary in America. It may appear at times, to readers who take overseas journals, that we are a little slow to present new ideas that are written up very enthusiastically elsewhere. If this is so, it is merely one manifestation of our policy of not publishing anything, however sensational it may be, unless it has our own technical backing. In high-fidelity work, hastening slowly is often as great a virtue as in other fields.



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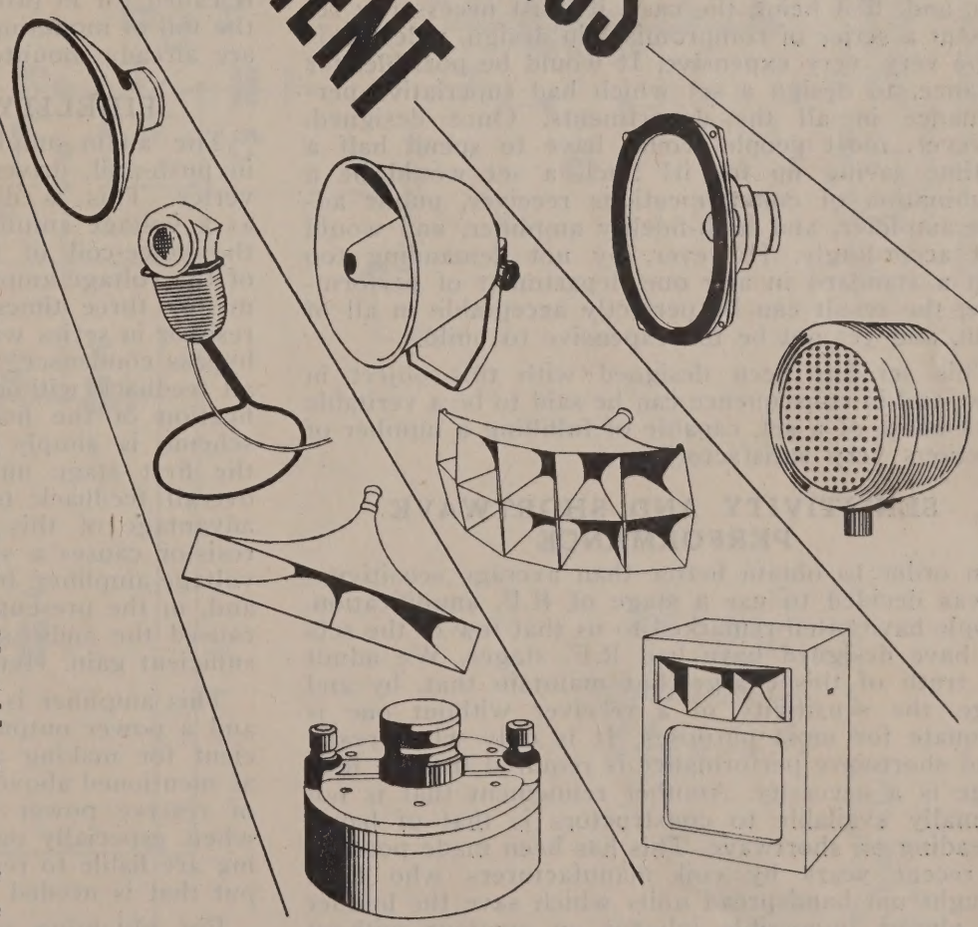

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A SEVEN-VALVE BANDSPREAD RADIOGRAM

The circuit described in this article has been designed to make use of a modern bandspread tuning unit, which comes to the purchaser ready wired up, from the aerial up to the first intermediate frequency transformer. It features simple and inexpensive circuitry, and boasts push-pull output and negative feedback.

INTRODUCTION

For those who want their radio set to act as a centre for home entertainment, there are several features that should be incorporated. First and foremost, it must include record-playing facilities. Secondly, it should preferably be an allwave set, to cater for those members of the family who want to listen to sports and other broadcasts from overseas. It should be sensitive, so that listening is not confined to local or moderately strong stations. It should be capable of a reasonably high standard of reproduction, so that the musically-inclined members of the family will be able to gain added pleasure from it, and will not be dissatisfied with its tonal qualities. It should have ample power output, so that, if necessary, it can be used for dance music, when it usually has to over-ride a high ambient noise-level. Now, a receiver that will do all these things is clearly versa-tile, and, that being the case, it must necessarily represent a series of compromises in design, unless it is to be very, very expensive. It would be possible, for instance, to design a set which had superlative performance in all the departments. Once designed, however, most people would have to spend half a lifetime saving up for it! Such a set would be a combination of communications receiver, public addres amplifier, and high-fidelity amplifier, and would cost accordingly. However, by not demanding too high a standard in any one department of performance, the result can be perfectly acceptable in all of them, and yet not be too expensive to build.

This set has been designed with this object in view, and in consequence can be said to be a veritable work-horse of a set, capable of fulfilling a number of functions very satisfactorily.

SENSITIVITY AND SHORTWAVE PERFORMANCE

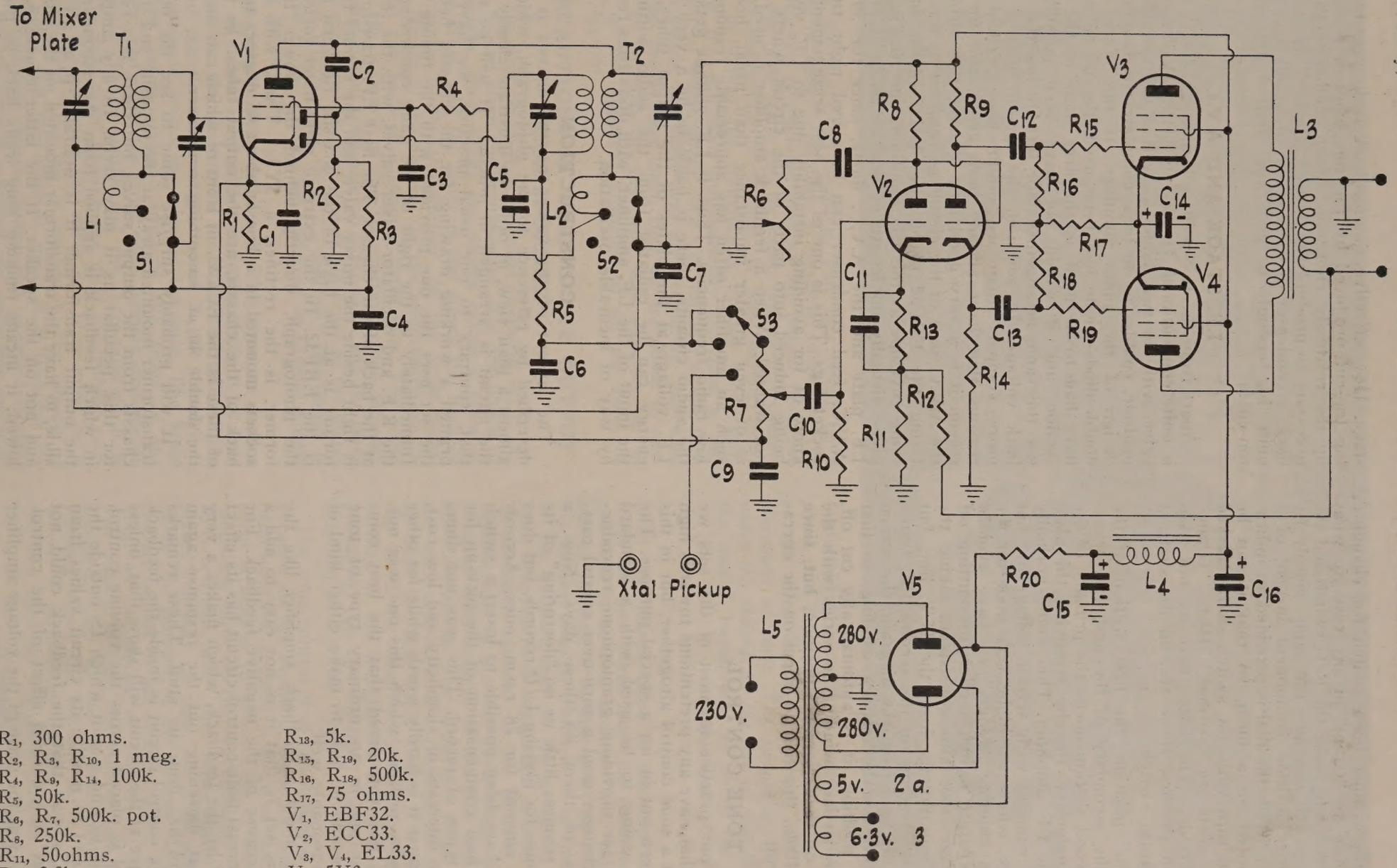
In order to obtain better-than average sensitivity, it was decided to use a stage of R.F. amplification. People have often remarked to us that few of the sets we have designed have had R.F. stages. We admit the truth of this charge, but maintain that, by and large, the sensitivity of a receiver without one is adequate for most purposes. It is only when really good shortwave performance is required that an R.F. stage is a necessity. Another refinement that is not normally available to constructors is that of bandspreading on shortwave. This has been made possible of recent years by coil manufacturers who have brought out bandspread units which save the builder the almost impossible job for an amateur without factory facilities, of building his own set of bandspread coils. The unit used with this set comes completely wired up from the aerial terminal to the output of the oscillator-mixer stage. Thus, all that the builder has to provide in order to finish up with a bandspread receiver is the I.F. stage, second detector, and audio section. The manufacturer evidently feels that, in order to ensure that every buyer of one of his bandspread units obtains first-class results, it is necessary for him to completely wire the "front end" in this way, and it certainly does save considerable time and trouble. The units are pre-aligned at the factory, and there should be no need for the user of this unit to re-align it after it has been built into a set. It is in one way unfortunate, however, that the unit cannot be purchased apart from the chassis on which it is built, for the said chassis is provided with mounting holes for octal or loctal sockets, to take the I.F. and audio section the user may decide to build. The effect of this is to tie the builder down to using these socket holes, and in the case of a set with a push-pull output stage, it is felt that a little more room, or else a different arrangement for the holes, would have been beneficial. However, there are compensating advantages in the arrangement, for, once the unit has been purchased, no further outlay is called for in providing a chassis, and one is saved the toil of mounting the dial, spinner, etc., since these are already mounted.

FIDELITY AND AUDIO OUTPUT

The audio amplifier comprises a pair of EL33s in push-pull, driven by a triode split-load phase inverter. This is direct-coupled to a further triode as a voltage amplifier, and feedback is applied from the voice-coil of the speaker back to the cathode of the voltage amplifier. A gain reduction of approximately three times is used; by inserting a 50-ohm resistor in series with the normal cathode resistor and bypass condenser, we are enabled to apply the overall feedback without appreciably affecting the amplification of the first stage itself. A very common scheme is simply to leave the cathode resistor of the first stage unbypassed, and then to apply the overall feedback to the cathode terminal. The disadvantage of this is that unbypassing the cathode resistor causes a substantial drop in the gain of the voltage amplifier, before the main feedback is applied, and, in the present case, such a practice would have caused the audio section of the receiver to have insufficient gain. Hence the use of the 50-ohm resistor.

This amplifier is capable of quite excellent quality, and a power output of some 9 watts, which is sufficient for making a very loud noise when required, as mentioned above. At the same time, there is plenty of reserve power in the amplifier for normal use, when, especially on "gram," the peaks of the recording are liable to require several times the power output that is needed for the average level.

For obtaining somewhat better results than the average from the high-powered local stations, we have incorporated two-position I.F. transformers which give a "narrow" and a "broad" selectivity characteristic at the turn of a switch. This scheme is well worth while, and yet costs very little to incorporate. The I.F. transformers cost very little more than ordinary ones, and the only additional component is the wafer switch. In the case of a radiogram,



R_1, 300 ohms.
R_2, R_3, R_{10}, 1 meg.
R_4, R_9, R_{14}, 100k.
R_5, 50k.
R_6, R_7, 500k. pot.
R_8, 250k.
R_{11}, 50ohms.
R_{12}, 2.2k.
R_{13}, 5k.
R_{15}, R_{19}, 20k.
R_{16}, R_{18}, 500k.
R_{17}, 75 ohms.
V_1, EBF32.
V_2, ECC33.
V_3, V_4, EL33.
V_5, 5Y3.

R_{20}, 500 ohms, or as needed to give 250v. at output of smoothing filter.
C_1, C_3, C_8, C_{10}, 0.05 μf.
C_2, C_5, C_6, 100 $\mu\mu$f.
C_4, 0.01 μf.
C_7, C_{12}, C_{13}, 0.1 μf.
C_9, C_{11}, C_{14}, 25μf. 25v. electro.

C_{15}, C_{16}, dual 40 μf. electro, 450v. working.
T_1, T_2, band-expanding I.F. transformers.
L_3, output transformer, 10,000 ohms to voice-coil.

Note.—The centre-tap of the output transformer has been omitted from the diagram. It should be joined to the main H.T. line.

like this one, there must be a switch for changing over from "Radio" to "Gram" in any case, so what we have done here is to make the R/G switch and the Narrow/Broad switch one and the same, simply by making it a three-position component instead of a two-position one. With the dial is provided an indicator plate, mounted on a bush, so that it can be attached to, and turn with, the switch shaft. Marked on the indicator plate are "Normal," "Hi-fi," "Gram," "Bass," and "Treble." The latter two are not used in this case, but the first three are, on the shaft of the selectivity/gram. switch.

In the "Gram" position, the first section of the switch opens the secondary of the first I.F. transformer. The second section opens the primary of the second I.F. transformer, thereby removing the plate voltage from the I.F. amplifier. This would normally leave this tube running with screen voltage on, but no plate voltage, which would be very poor for the valve, so, by a cunning "dodge," we have avoided the use of a separate switch section for cutting off the screen voltage, too. This consists in taking the screen voltage not directly from the H.T. line, but from the tertiary winding on the second I.F. transformer. As can be seen from the diagram, the screen supply is fed through the tertiary winding, so that in the "Gram" position, it is automatically cut off. This places the tertiary winding in series with the screen resistor on the "Narrow" position, but, since the resistor is 100k., this has no effect on the operation of the circuit.

TONE CONTROL

It has been our practice in most of the sets we have designed that have any pretentions towards high quality, to omit a tone control altogether, but in this case one has been put in for a special purpose. The prototype was going to be used with a standard record changer for providing gramophone reproduction, and this changer used a turn-over crystal cartridge, as many of them do these days. Now, a crystal pick-up requires little or no "doctoring" of its frequency response for playing L/P records, but does need a certain amount for 78 r.p.m. ones. Accordingly, it would have been possible to insert a switch for giving the best compensation of the pick-up for the two main types of record. This was not done, however, in the interests of simplicity and low cost, particularly because it is hardly worth while for other than a high-fidelity pick-up, which this one was not. Accordingly, it was considered that the best compromise was to put in an ordinary type of tone control, which would be able to make either kind of record sound reasonably well.

One difficulty about a feedback amplifier like the one used in this set is that it is not easy to add a tone control, because of the negative feedback. For instance, any normal tone-control circuit has its effect largely nullified by the feedback, which makes a very good attempt at flattening out the response again after the control has done its stuff. These remarks apply only if the control circuit is inside the feedback loop, but a glance at the circuit will show that, unless the tone control is placed across the volume control, it is not possible to find a spot which IS outside the feedback loop, and to modify its circuit values from normal in such a way that the feedback could not "compensate out" the desired effect of the control. The spot chosen was the plate of the voltage amplifier stage. How effective the feedback is in neutralizing the top-cut produced by the tone control is shown by the relatively enormous shunt condenser that is necessary to produce the desired effect. Without feedback, a condenser of 0.002 μf. or so would have been quite big enough to give any desired amount of top-cut!

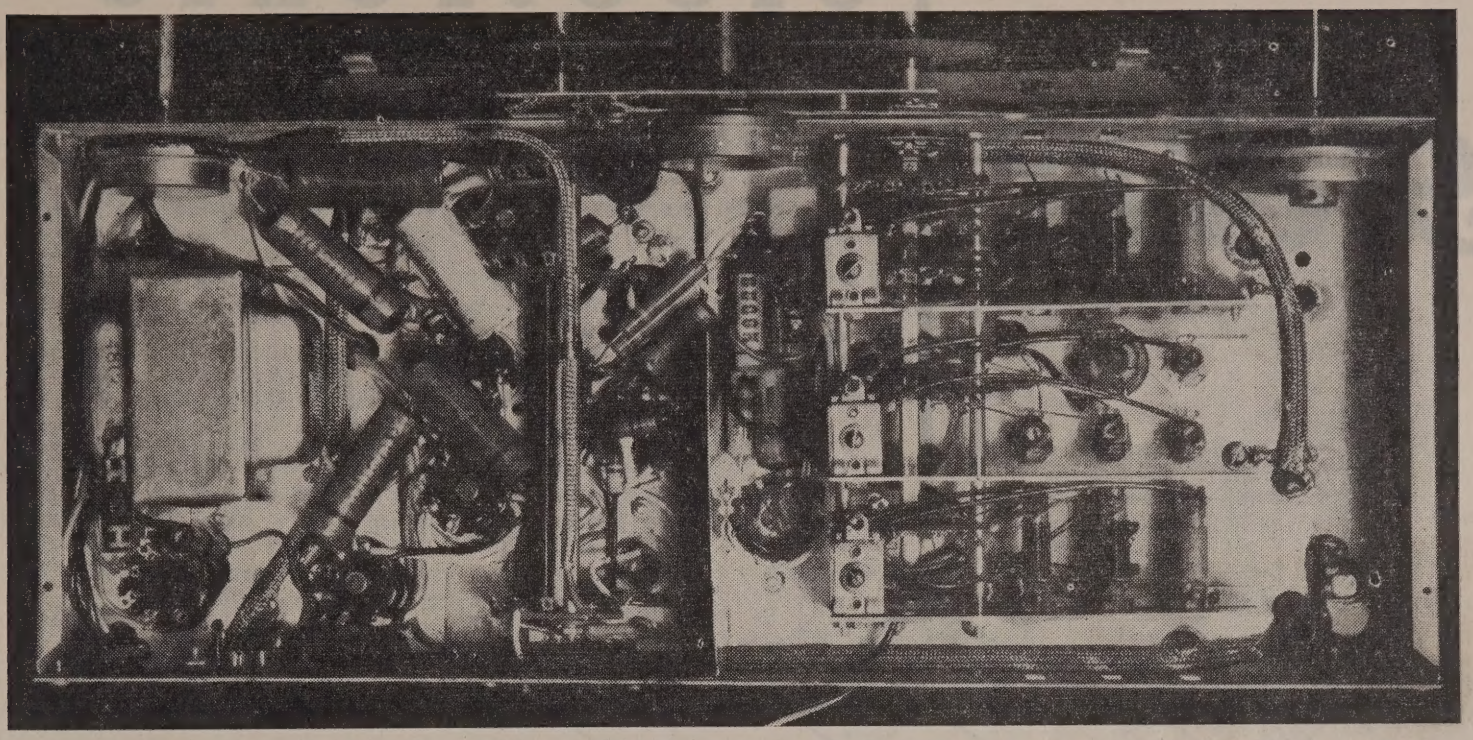
I.F. STAGE AND A.V.C.

Apart from the two-point selectivity, the I.F. stage is quite conventional. It uses an EBF32, because this valve, with the two diodes as well as the variable-mu pentode, enables us to have complete freedom in the design of the audio amplifier. If the more usual double-diode-triode had been used, the triode would have had to be used as the first stage of the A.F. section, and it would not have been possible to use the same arrangement for introducing the feedback voltage. In addition, the lay-out was a little more compact than we might have wished, for reasons that have already been given, and for this reason it is a very good idea to have the wiring of the A.V.C. part of the circuit as compact as possible. Using the EBF32 places the A.V.C. diode in the same envelope as the I.F. amplifier, and this in turn gives virtually no length of lead at all between the I.F. plate and the A.V.C. diode, since the 50 $\mu\mu$f. A.V.C. feed condenser can be wired right to the socket lugs. This is one of the best arrangements we know of for avoiding instability due to I.F. voltage being induced into parts of the circuit where it is not wanted. When a feedback amplifier is used, this is of even greater importance than usual, because such an amplifier often has appreciable response at low radio frequencies. Thus, if I.F. voltage gets into the audio circuits, there is liable to be a very large I.F. voltage at the plates of the output tubes, and energy can be radiated from the audio wiring to the input of the I.F. amplifier, with disastrous results, by way of incurable oscillation.

CONSTRUCTION

The lay-out of the valves on the chassis is best described by reference to the photograph, which is almost a plan view, in order to illustrate clearly how the circuit is arranged in practice. It will be noted that, contrary to our usual practice, we have not printed a working drawing for the chassis, because the set uses the one provided with the tuning unit. Immediately to the right of the gang condenser are the R.F. and oscillator-mixer valves, with the former at the back of the chassis. The first I.F. transformer is right beside the mixer valve, and the second transformer is at the back of the chassis. Between them is the EBF32. In the extreme right-hand corner in the photograph, directly behind the power transformer, is the rectifier, a 5Y3. Then, with their sockets mounted in a line at about 45 degrees to the back of the chassis, are the output tubes. In front of these is the ECC33, in front of which can be seen the double 40 μf. smoothing condenser.

It will probably surprise some to see the output transformer mounted away at the opposite end of the chassis from the output valves, but there is a reason for this, peculiar as it may seem. In any amplifier in which feedback is applied from the secondary of the output transformer it is desirable if at all possible, to have the transformer mounted on the chassis, and not on the speaker. If the latter course is followed, it means running long leads back to the set



Under-chassis view of the receiver. This should be compared with the photograph of the set on the front cover of this issue in order to obtain a clear idea of the placement of parts. The smoothing choke can be seen under the chassis, to the left in this photograph, while the output transformer is above the chassis, at the other end.

from the voice-coil winding, and this could be a source of audio instability. If possible, of course, the transformer is mounted next to the output tubes, so that the plate leads can be short, but on this chassis it was impossible to do this. It was feasible, however, to mount the transformer on the other side, where the coil unit automatically provides a fair amount of waste space. We did not like doing this, on principle, but there was no alternative, and with the few precautions taken that we are about to outline, no trouble of any sort was experienced, in spite of the apparent violation of all the rules of good lay-out.

PRECAUTIONS IN WIRING THE OUTPUT TRANSFORMER

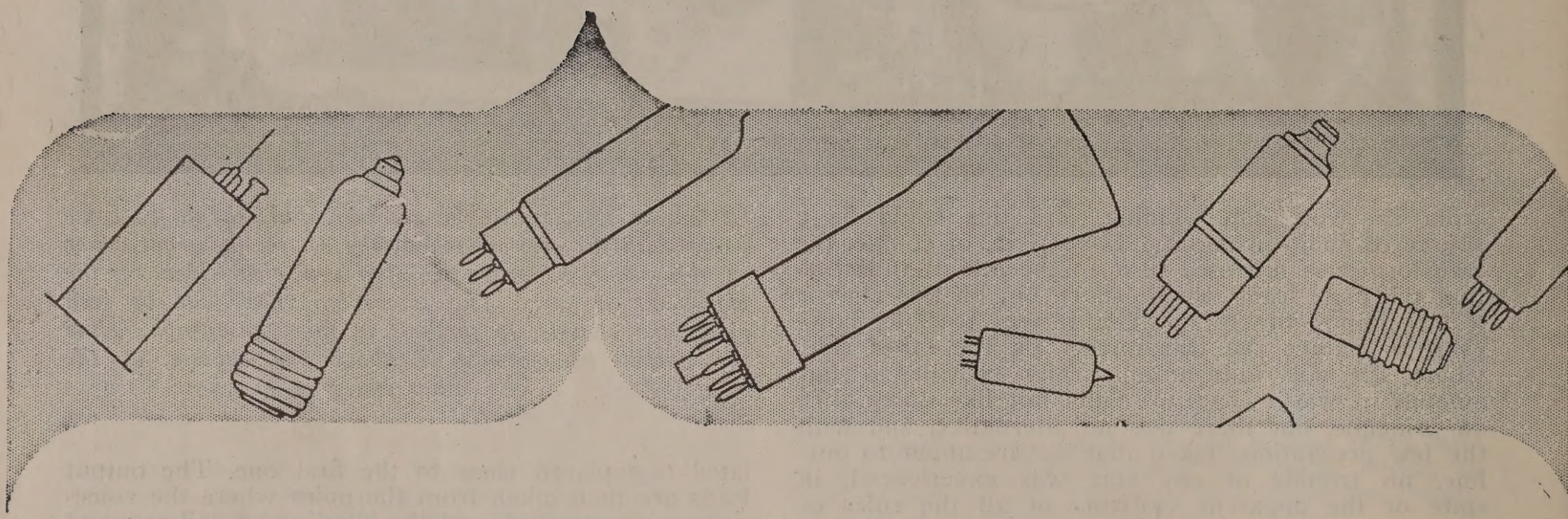
In the first place, it is essential to shield ALL the leads to and from the transformer. For the plates of the valves, three wires are placed inside a piece of shield braid, and the latter is run round the back of the chassis to the transformer. In the front right-hand corner of the chassis (in the underneath photograph) can be seen a strip of three tags. The wires from the primary of the transformer come through a grommet and terminate on these tags, and the three wires are taken through the shield braid to the plates of the EL33s, and to H.T. positive. The braid is earthed to the chassis by soldering at several points along its run.

Now for the voice-coil leads. This time we need a piece of shield braid with two leads inside it. A hole is made in the chassis on the voice-coil side of the output transformer, and the braid is put through it and soldered round the edge of the hole. The braid is then taken straight towards the front of the chassis, and along the front edge, passing underneath the wave-change switch and the three-position R/G switch. Just after passing the dual electrolytic condenser, it stops, and the wires are terminated on a two-tag strip. One tag is earthed to the chassis at this point and the other is used as a tie-point for the 2k feedback resistor, which can be wired straight from the tag strip to a second one, with only one insulated tag, placed close to the first one. The output leads are then taken from the point where the voice-coil wire is earthed, and the "hot" voice-coil tag, and passed through a further piece of shielding braid to the speaker socket, which is to be found on the back of the chassis, next to the grommet for the power lead. The feedback connection is then made from the 2k feedback resistor to the 50-ohm resistor in the cathode lead of the first audio stage, which is handily situated with respect to the two tag-strips we have been discussing. The important thing to note is that the voice-coil is NOT earthed at the transformer, but up near the first audio stage. If a single lead were run from the "hot" voice-coil lead, the other being earthed at the transformer itself, there would in all probability be trouble from oscillation of the audio amplifier as a whole.

The tone control was not mounted on the chassis, because all the available holes for control shafts had been used up. Instead, a piece of steel or aluminium sheet is held to the front edge of the chassis by the mounting nuts of the wave-change switch and the R/G switch, and the tone-control potentiometer placed centrally on this. The plate extends only 2 in. below the bottom of the chassis. It means that the chassis cannot be sat straight down on the shelf, but must sit on blocks or runners at least 2 in. deep. The wiring to both the volume and tone controls is shielded. That to the volume control can be seen running along the bottom bar of the R/G switch, where it terminates on the back wafer, which is the one used for the R/G portion of the switching,

(Concluded on page 48.)

G.E.C. | electronic devices



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For the Amateur

Some Notes on Super-regenerative Receivers

This article details some of the features of the super-regen. that can be expected to appeal to the amateur, and gives some useful tips on the best kind to build, and how to get it going. The points illustrated are brought out by reference to a newly-designed super-regenerative radio control receiver using sub-miniature hearing-aid valves.

SEPARATE QUENCHING

Several years ago one used to see circuits for super-regenerative detectors in the amateur literature. They were recommended for use on frequencies such as the 6-metre band, which in those days were called "ultra-high." These days, there is little difficulty in making a super-regen. work well at frequencies as high as 500 mc/sec. and comparatively low frequencies like 27.12 or 35.4 mc/sec. are "a piece of cake." Those who have read the aforesaid amateur handbooks will have noted that there are two kinds of super-regenerative detector, known respectively as self-quenching and separately quenched. The latter type is more complicated to look at, since it uses two valves, or at least a double triode, and as such is usually shunned by the newcomer to super-regeneratives. Unfortunately, this is the wrong answer, and is is only too usual to find that those who have tried the super-regen. have long since cast it out as "unreliable" or "tricky to get going," or even "couldn't get it to work at all, O.M." This is most unfortunate, because the separately quenched variety, although it contains slightly more parts, is by far the better proposition. It is not "touchy" at all, it is more sensitive than the other, and not in the least unreliable. Contrary to popular supposition, it can be made reasonably selective, although it will not of course, approach a superhet. in this respect.

CAN YOU BUILD AN OSCILLATOR?

This would be our question to anyone who says he could not built a super-regenerative receiver. For a separately quenched one is nothing more nor less than two oscillators; they can be built as entirely separate devices and made to work separately as oscillators. All the usual tests for oscillators can be applied to ensure that they are working properly, and, once they are, a simple method of interconnecting them turns them from two oscillators into a super-regenerative detector. After that, all that is needed is an audio amplifier, and away we go! It really is as simple as that.

WHAT ABOUT THE TWO OSCILLATORS?

For the benefit of those readers who have not met this kind of receiver before, or at least not intimately, we should perhaps explain briefly how it works. It gets its name from the fact that a regenerative detector can sometimes be made to super-regenerate simply by increasing the amount of regeneration. What happens in a case like this is that there is a loud "plop" as one increases the reaction, and at all higher settings a loud hissing noise is heard. This noise is characteristic of the super-regenerative detector, and acts as a very simple indicator that the thing is working properly. The exact mechanism

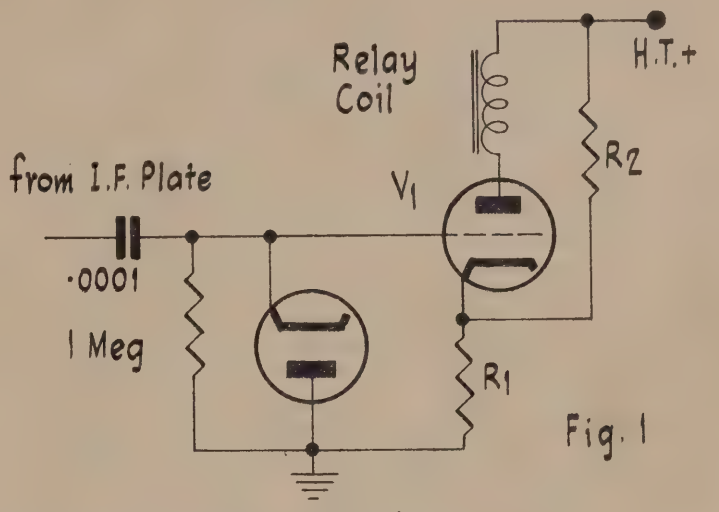

Fig. 1

R1 & R2 chosen to bias V1 at or near cut off

of this sort of detector we have not time to go into at the moment, but, put very briefly, what the detector is doing when it goes into super-regeneration is to oscillate simultaneously at the radio frequency to which it is tuned, and to some very much lower frequency. Should this frequency be too high for audibility, we will have super-regenerative action, as described, but should the low frequency turn out to be below 10,000 c/sec., we will hear it as an audible squeal. The difficulty associated with making self-quenching detectors function reliably is simply that of making the tube oscillate at the two frequencies at the same time, without the low-frequency oscillation getting so low that we can hear it directly. Put another way, the valve acts as a self-modulated oscillator, the modulation frequency needing to be 20,000 c/sec. or higher. Of course, none of what we have said has constituted a real explanation of how the valve does these things; it has been merely a statement of what it does when it is super-regenerating. But it is not difficult to go on from here and see what the two separate oscillators are supposed to do. If we take a low-frequency oscillater on, say, 50 kc/sec., and use it to modulate an oscillator which is working on the radio frequency we hope to receive, then we will have a super-regenerative detector. There is only one proviso we must add to this: It is not just sufficient for the R.F. oscillator to be modulated in amplitude by the L.F. oscillator. The latter must put it in and out of oscillation once in every cycle of its own oscillation. That is to say, if the L.F. oscillator is on 50 kc/sec., the R.F. oscillator must go in and out of oscillation once in every 50 kc. cycle. If the L.F. oscillator

merely modulates the amplitude of the R.F. oscillator without stopping it, then there will be no super-regeneration. Now there are a number of other reasons why a super-regenerative detector of the separately-quenched type may not work properly, but they can easily be dealt with if and when they occur.

SUPER-REGEN. CIRCUITS

Now, since the detector consists only of two oscillators, on different frequencies, coupled together in a particular way, it is reasonable to suppose that there are no restrictions on the actual oscillator circuits used. Either of them may be ordinary tickler feedback oscillators, or they may be Hartley, Colpitts, Ultra-audion, or any combination of them. Since low-frequency oscillators are very easy to make, whatever type of circuit is used, any desired one may be used as the quench oscillator, as the L.F. one is usually called. Which one will be chosen for the R.F. oscillator is largely a matter of convenience. Where the radio frequency is high, this often amounts to using any oscillator circuit that will function at that frequency with the valve chosen. The best all-round circuit to use is the Colpitts, because this can be made to work with almost any valve at any frequency the valve will reach. It is for this reason that the Colpitts was decided upon for the receiver illustrated here. This was designed to use hearing-aid valves and batteries, on account of their small size and weight, but the same considerations apply here as to any other valve. The choice of circuit has nothing to do with the particular application, because, had the project been to produce the receiver portion of a handie-talkie, for example, the choice of valves and batteries would have been the same. Now, hearing-aid valves have a very low mutual conductance compared with full-sized valves, so that, although their small size helps them to work at quite high frequencies, their low Gm does not, and it is found that their upper limit of oscillation is not as high as might be expected. (For those interested, it is in the region of 150 mc/sec.) Consequently, even at fairly low frequencies such as are used for remote control, it is of advantage to use one of the better oscillator circuits. For the quench oscillator, a Hartley was used, because it requires only a simple centre-tapped coil, easy to make and wire up.

SUPER-REGENERATIVE REMOTE-CONTROL RECEIVERS

Since we printed our first article on this rather out-of-the-way branch of radio, we have been surprised at the number of readers, both at home and overseas, who have written to us asking for further information or for advice on specific aspects of the general problem of remote control. Practically all these people have been modellers, whose interest in remote control sprang from a keenness for model aircraft or boats. However, there are numerous other applications for radio-control equipment, from automatically opening garage doors to calling devices for radio telephones, and remote tuning of receivers and transmitters! Except for applications like the latter, which call for more advanced circuits, the majority of applications call for nothing more complicated than closing a relay when a signal is sent by the control transmitter. Provided a full-sized receiver, run from the mains in the ordinary way, can be used, the problem presents very little difficulty. For example, a simple superhet., with A.V.C., can be modified very easily so that it will close a relay on receipt of a signal stronger than a predetermined amount. All we need to add is an additional detector circuit and a relay valve. The latter can be biased at or near cut-off, and the diode can be arranged to give a positive output with respect to earth. It would be direct-coupled to the grid of the relay valve, so that, when a signal is received, the diode makes the grid of the relay tube go more positive, thereby causing a sufficient increase in current to operate the relay. The scheme could use a simple circuit like that of Fig. 1. Almost any desired relay-tube current could be controlled in this way, and there would be no difficulty about it at all. Often, however, the control equipment needs to have very low current consumption, either because it is required to be carried by a model aircraft, with a pay-load of no more than a pound weight, or because it must be operated continuously, as, for example, in the calling system mentioned above. For applications like this, the size, weight, and current consumption of a conventional radio set would be prohibitive, so that specially designed receivers must be used.

Much of our own experimental work has been done with model aircraft as the objective, both because flying these is a pleasant outdoor occupation for the week-end and because, if the restrictions of size, weight, and battery consumption can be met for this application, it is a very simple matter to modify equipment for other, less rigorous, applications.

SUPER-REGENERATIVE RECEIVERS IN GENERAL

What all this boils down to is that we must obtain the highest sensitivity in the smallest number of valves; it is obviously a case for that oft-maligned object, the super-regenerative receiver. Contrary to what many people think, this type of receiver can be made as foolproof and reliable as any other. Its sensitivity is exceedingly good, and it has an inherent A.V.C. action which is a very great advantage for this sort of work. It means that there is no such thing, almost, as partial operation. The relay will operate right out to extreme range, whereupon a small increase in range causes operation to be lost completely. So sensitive is the receiver, however, that "extreme range" means a place where the signal is only a few microvolts, so that in practice it is never reached.

It is true that the super-regen. is a difficult animal to make work if one is relying solely on information printed about it up to about 1950, but since then many articles have appeared in various publications explaining in detail the principles of the thing, and thus giving the interested reader a very good idea of what to do about it if he can't get one to work. The circuit presented in this article is one which has been evolved to have the essential feature of reproducibility, together with the other attributes of the super-regenerative circuit.

SOME GOOD ADVICE

If you are thinking of building a super-regen. for any reason whatever, and even if you are copying a design that has been fully tested (as "R. & E" ones always have), it is a very good plan to proceed along the following lines. Build up the quench oscillator first, in its proper position on the chassis, and turn it on before going any further. Then treat it as if

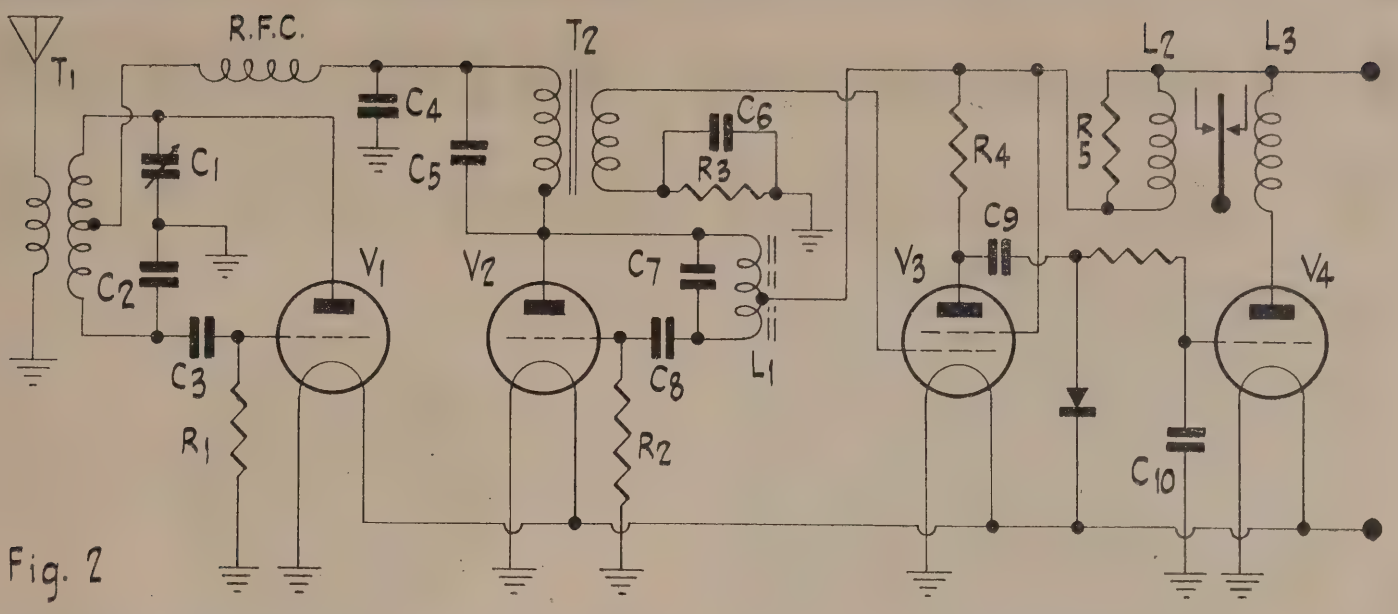

Fig. 2

it were a transmitting oscillator by temporarily connecting a 0-1 ma. meter in series at that earthed end of the grid leak. If all is well, oscillation will be indicated by a substantial amount of grid current. Not that any difficulty is to be expected here, provided that the components are satisfactory. But once the oscillator has been found to work, we can forget about it in the certain knowledge that if we do strike trouble later on, it will not be because the quench oscillator is not working. No one would think of building a complete phone transmitter without first ascertaining that the R.F. and audio sections work properly independently of each other before connecting them together and speaking into the mike. By the same token, it is only common sense to do the same with a super-regenerative set.

Next, the R.F. oscillator is built. It will be noted that the H.T. supply for the R.F. oscillator comes, not from the H.T. line, but through the primary of the audio transformer, from the plate of the quench oscillator. The arrangement is very similar to that of the old-fashioned Heising modulator, in which the modulated amplifier was fed from the plate of the modulator tube, through a dropping resistor bypassed by a condenser. Here the transformer primary takes the place of the dropping resistor, and a condenser shunts the winding, in order to pass the output of the quench oscillator (which in this case is the modulator) on to the plate of the R.F. oscillator. If this condenser were not there, the primary of the transformer would present a high impedance to the quench frequency, with the result that little would be applied to the R.F. oscillator.

When the latter has been built, it should be checked in the same way as the quench oscillator. It is even more important in this case to ensure that it is working properly as a C.W. oscillator before we attempt to modulate it. To do this, all that is necessary is to "pull" the quench oscillator. This leaves all the conditions as before, except that it removes the quench voltage. Under these conditions, the oscillator should be working continuously, and should show a small but definite grid current, of a few microamps—enough to show on a 0-1 ma. meter. A further check is to look at the plate current, which will be quite small—several hundred microamps—and then short the grid to earth. This will stop the oscillation, and a rise of plate current should occur. If

COMPONENT LIST

C_1, 2-10 $\mu\mu$f. variable.
C_2, 10$\mu\mu$f. fixed.
C_3, 25 $\mu\mu$f.
C_4, 100$\mu\mu$f.
C_5, 200 $\mu\mu$f.
C_6, C_9, C_{10}, 0.01 μf.
C_7, 500 $\mu\mu$f.
C_8, 0.001 μf.
T_1, aerial coil, to suit required frequency.
T_2, miniature audio transformer turns ratio 4:1 approx.
R_1, R_6 (unmarked), 1 meg.
R_2, 50k.
R_3, 5 meg.
R_4, 100k.
R_5, adjusted to give 0.5 ma. through L_2, with no signal applied.
V_1, V_3, DL71.
V_2, V_4, DL72.

Note.—V_1, V_2, and V_4 are all triode-connected by connecting screen-grid to plate.

there is no rise at all, it is an indication that the tube is not oscillating. On the other hand, if the plate current is very small—much less than 100 microamps—it indicates that the oscillator is "squegging." If this is the case, the valve will probably be acting as a self-quenching super-regenerative when we do not want it to, and, before we go any further, this has to be cured.

A further check which will confirm this fault can be made by placing a pair of headphones across the secondary of the audio transformer, and if self-quenching is taking place, the usual super-regenerative hissing noise can be heard. The usual reason for self-quenching when this is not wanted is that either the grid condenser or grid leak, or both, are a good deal higher in value than the circuit specifies. Making either of them a bit smaller (but not too much) should cure the squegging. If the circuit is found not to be oscillating at all, look for faulty components. It has not been unknown, for instance, for a 50k. resistor to be wired in in place of a 500k., because of the difficulty of reading the colour code in artificial light! Or, for that matter, for a 500 $\mu\mu$f. condenser to be wrongly used in place of a 50 $\mu\mu$f.!

If, as is most likely, the R.F. oscillator is found to be satisfactory, then it is possible to proceed to

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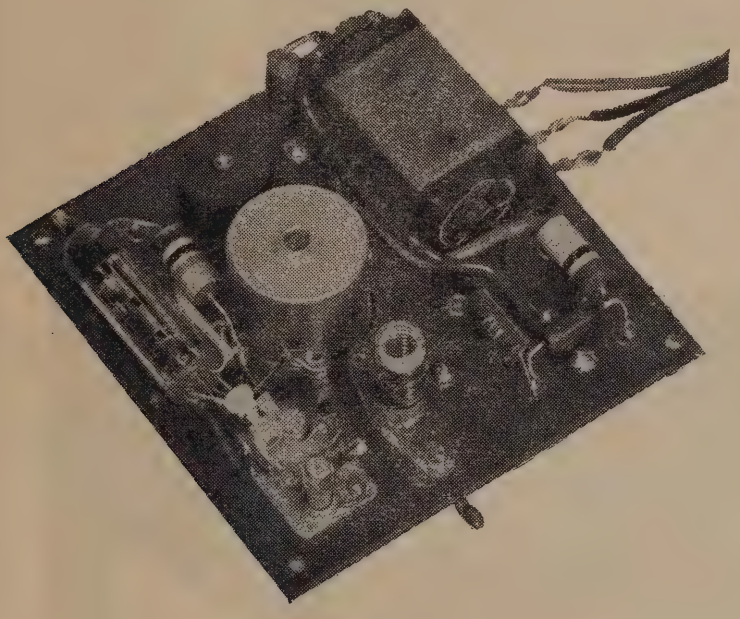
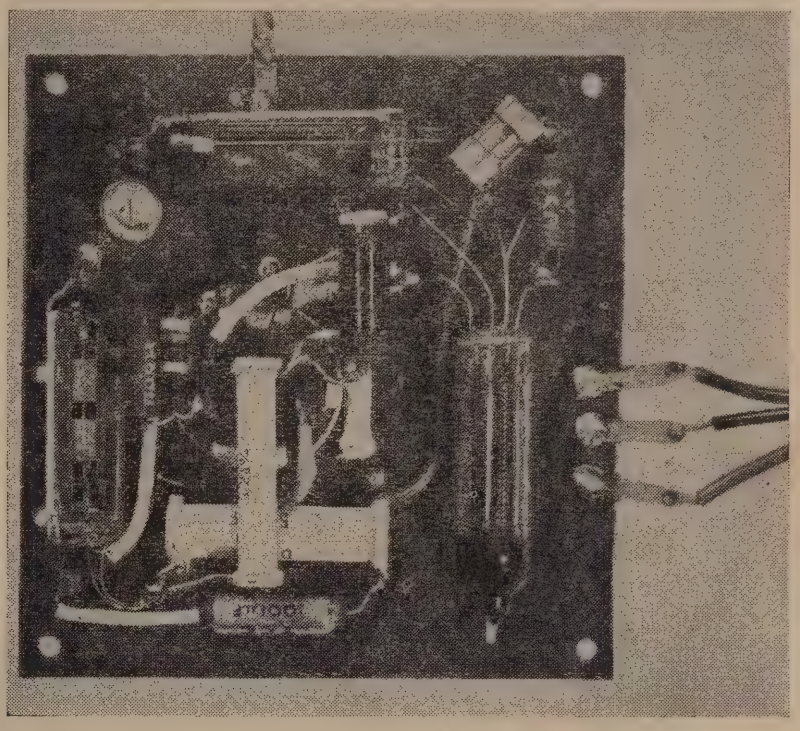
the next step, which is to plug in the quench oscillator again and listen to the detector's output on the headphones at the secondary of the audio transformer. With a bit of luck, a quite loud super-regenerative hiss should now be heard, and the detector is functioning. When testing in this way, care should be taken to see that the tuning condenser is between half and full mesh, because even when the circuit is working properly, it may cease operation at small settings of the tuning condenser. This is characteristic of the circuit, and is not a fault. The reason is that a true Colpitts circuit uses a split-stator tuning condenser. This one does not, since the application does not call for continuous tuning over a fairly wide range. Varying only one of the capacities across the coil alters the feedback at the same time as it does the tuning, which accounts for the possible drop-out at low settings. Once the circuit is working, a check should now be made to see that it is somewhere near the desired frequency. If it is not, then the number of turns on the coil will have to be changed until the frequency is obtained, with the variable condenser set at about half-scale. If a dead spot is found in the tuning range, it will probably be due to the reception of a weak signal. The sensitivity is enormous, so that, even without an aerial, it is quite possible for signals to be received. If these are unmodulated carriers, then the effect will be the same as if the circuit went out of super-regeneration over a small part of its range.



Should super-regeneration not be obtained, even if both oscillators have been found to be working properly, there can be only one reason—the wrong amount of quench voltage is being fed to the R.F. oscillator. The cure for this is to experiment with the value of the condenser shunting the transformer primary. A value will be found which gives the loudest super-regenerative hiss with the smoothest sound.

AERIAL COUPLING

Once the circuit is working, the final job is to couple the aerial to it. For remote-control purposes, the only aerial that can be used is a few feet of wire, unless the application is one in which the receiver is at a fixed location, but, whatever the aerial used, the best results will be obtained by a small amount of juggling with the aerial coupling. It will be found that, if the latter is too tight, the detector will be pulled out of super-regeneration, but that if it is too loose, the sensitivity is not as great as it could be. In practice, it is found that the greatest sensitivity is obtained just before the point where the aerial stops the super-regeneration, and this is the best spot to adjust the aerial coupling. It can be recognized by the fact that, just before the detector falls out, the loudness of the hiss increases. The adjustment is not too critical, and can be done quite easily.



Above: Underneath view of the set, where most of the wiring appears except for that of the R.F. oscillator.

Left: Top view of the control receiver. The round object in the centre is the midget A.F. transformer, and the relay is at the right-hand back corner. The R.F. oscillator components are in the front left-hand corner, and the small pot-type core for the quench oscillator is behind the audio transformer.

THE REST OF THE RECEIVER

If the receiver is for communication, all that is needed after the detector is as much audio amplification as may be needed, either for phones or for speaker operation. The output of the detector is great enough to require only one stage of audio for working phones at an uncomfortably loud level, and, if a speaker is used, one low-gain voltage amplifier followed by a power stage will be plenty.

For control purposes, the circuit can be followed up as shown in the diagram. This receiver, of which photographs are shown, was designed specially for use with an Elliott relay, which is a polarized moving-coil relay, closing with 150 μ amps, through either coil. Normally, with no current through either coil, neither contact is made, and for this purpose it was necessary to have the relay working as a change-over switch, with one contact making with no signal applied to the set.

In order to secure this sort of operation, a portion of the H.T. current of the detector and A.F. amplifier

section is passed through one of the coils, biasing the relay over on to one contact. Then, when the relay valve operates, it passes enough current through the second winding not only to overcome the pull of the first winding, but also to pull the contact over on to the other contact. If a conventional relay is used, it should have one pair of change-over contacts, and will, of course, have only one coil. This is placed in series with the plate of the relay valve, and causes the relay to operate when a signal is sent.

The third valve in the receiver is an audio amplifier, and it is followed by a crystal diode. This is polarized so that its D.C. output is negative with respect to ground, and, under no-signal conditions, the super-regenerative hiss is amplified, rectified, and applied as a negative D.C. bias, almost cutting off the plate current of the relay valve completely. When a C.W. signal is received, the hiss disappears, and the bias with it, so that the relay tube's current immediately jumps to its full value, operating the relay. As the receiver is shown, the current change in the DL72 relay valve is from zero to more than 3 ma., when the H.T. voltage is 45. However, 3 ma. is much more than the rated maximum plate current of the DL72, and this valve cannot be allowed to operate under these conditions. In practice, this receiver was designed to run from an H.T. voltage of 22½, which it does very successfully. The relay tube then draws 1.2 ma. under signal-on conditions. This is quite enough to operate the sensitive relay.

Should it be desired to operate a more robust relay, the best plan would be to run the receiver off 45 volts, and substitute a 1S4 or 3S4 or the DL72 relay tube. This will give a current maximum in the relay tube of from 6 to 8 milliamps, according to the type and condition of the valve, and is enough to operate a relay with only moderate sensitivity.

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LABORATORY NOTES
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THE DECIBEL

Because the human ear detects changes of power level in roughly the logarithmic ratio of the two powers and the acoustical output of a loudspeaker is proportional to electrical changes in the circuit that feeds it, a logarithmic basis of comparing power changes is often used. The logarithm to the base 10 of the ratio of two powers is known as the bel. This unit is rather large for ordinary use, and the decibel (one-tenth of a bel) is commonly used.

As a power change expressed in decibels is a ratio only, it is necessary to specify a standard reference level before any value of power can be computed from the figure given. A standard reference level expressed as zero db. for 1 milliwatt into a stated resistance is common. This is the level used by BEACON when rating the maximum operating level of small audio transformers.

A very good source of information on the decibel is found in the fourth edition of the "Radiotron Designer's Handbook."

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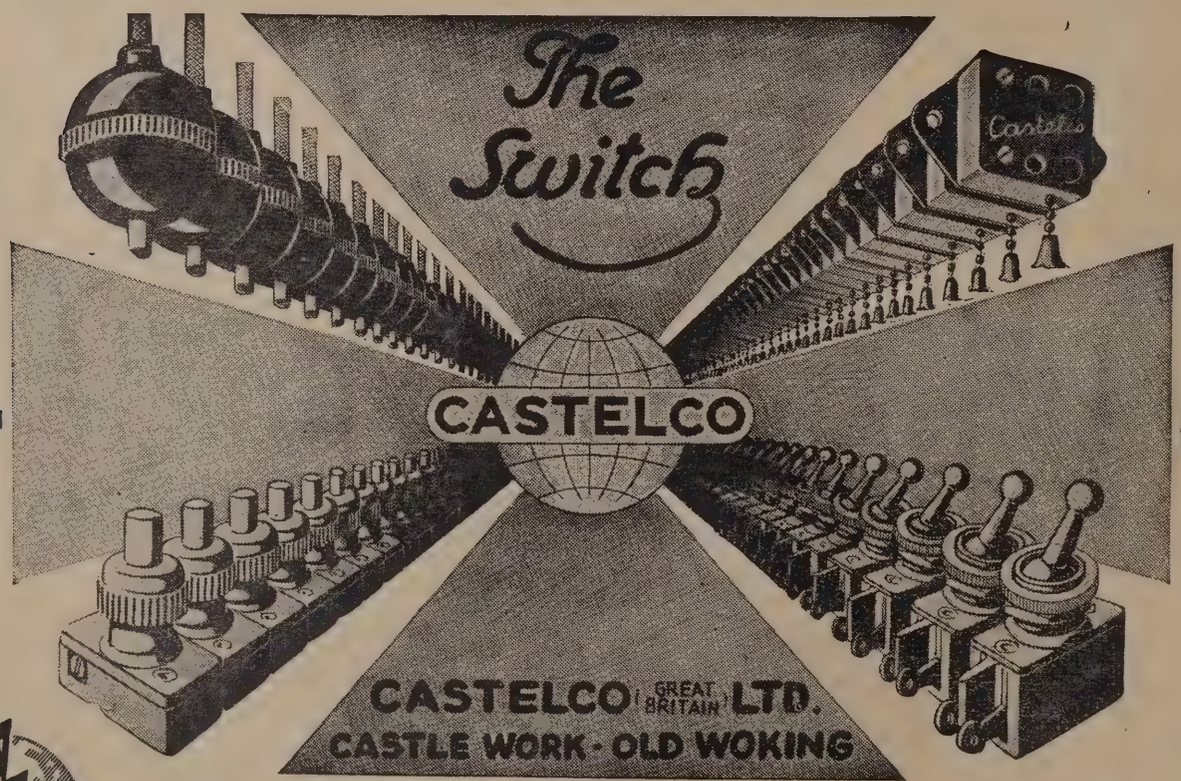

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THE CHOICE OF A TELEVISION STANDARD

Report of a lecture given in Wellington by Mr. N. R. Palmer, M.Sc., A.M.I.E.E., before the Wellington sub-branch of the British Institution of Radio Engineers.

On Monday, 2nd November, Mr. N. R. Palmer delivered a most interesting address to the Wellington sub-branch of the British Institution of Radio Engineers. The lecture was attended by a large number of members and visitors, and was followed by supper.

Mr. Palmer, together with Mr. S. W. McDonald, another of the New Zealand Broadcasting Service's engineers, was in 1951 entrusted with the task of visiting Europe, Great Britain, and America, where they were to view existing television services and to bring down a report recommending standards considered suitable for use in New Zealand on the commencement of a television service. At the beginning of his talk, Mr. Palmer outlined events in New Zealand which led up to their mission, after which he embarked on a review of the details of a television standard, and evaluated the importance of each. In the course of his remarks, some very interesting points emerged. They went away, Mr. Palmer said, with no preconceived ideas as to the relative merits of the various standards that were in use, and without a very clear idea of which of the many technical points involved had the greatest significance.

The main consideration, once a technically suitable standard was established, was the way in which that standard affected the economics of receiver manufacture. Mr. Palmer gave as his reason for this statement the fact that, in spite of the high capital cost of transmitting and studio equipment, the highest cost to be faced by the public was ultimately the money expended in purchasing receivers. Thus, by far the most important aspects were those which had an effect on the manufacturing cost of receivers.

It was interesting to note that the American 525-line standards were designed round the fundamental fact that the channel width of 6 mc/sec. had been laid down in advance. The design of that standard thus consisted in attempting to make the best possible use of that channel width.

Mr. Palmer indicated that in carrying out their mission, Mr. McDonald and he had kept before them the necessity of retaining an attitude of responsibility in the matter of preserving channel width. They had to remember, he said, that the requirements of other services for channel space were such that they must avoid recommending any standards which would be wasteful of bandwidth. The latest developments in colour television were such that, even if a 405-line system were recommended and put into operation, this would not preclude the addition of colour at a later date, and when this came about, it would not take up any more bandwidth. Of all systems in operational use, the BBC one was most economical of channel space.

PICTURE FREQUENCY

In determining the best picture frequency to use under given conditions, several things had to be taken into account. Perhaps the most important was the frequency of the mains in the greater part of the country to be served. In America, this was predominantly 60 c/sec., while in Europe and England it was 50 c/sec., as in New Zealand, so that America had decided on a picture frequency of 30 per second, while Britain and Europe, though their standards dif fered markedly in other respects, had chosen 25. There was also the question of whether or not the television picture frequency should operate in synchronism with the mains. From the point of view of flicker, the advantage of a high picture frequency was very much greater than in direct proportion to that frequency. For example, Mr. Palmer showed curves which related the minimum observable flicker to the picture frequency, and these showed that the reduction in flicker caused by raising the picture frequency from 25 to 30 a second enabled the maximum brightness in the case of the latter to be some five times the figure attainable with 25 pictures a second, without flicker being objectionable. Even so, a more important consideration still was that of running the system synchronously with the mains, since this has an important bearing on the amount of hum tolerable in a receiver. Synchronous working greatly eased the smoothing requirement in receivers, and therefore rendered them less costly.

LINE FREQUENCY AND NUMBER OF LINES PER PICTURE

The question of the number of lines per picture had to be approached from two points of view, Mr. Palmer said. First of all, how many lines could be considered to produce a satisfactory degree of resolution for the purpose of home entertainment? With the acuity of the eye taken into account, together with the known preference of viewers for looking at the picture from a distance of between five and eight times the picture height, it is estimated that acceptable results can be produced with a balanced resolution of about 300 to 350 lines. This is the figure actually achieved in the British 405-line system, with its normal video bandwidth of 3 mc/sec. If this is regarded as a minimum acceptable figure, then any increase in the number of lines must be evaluated in terms of the improvement in picture quality, as against the additional bandwidth necessary if equal horizontal and vertical resolutions are to be retained. In coming to a dicision on this point, they were influenced by what receiver manufacturers in all countries that were visited were able to accomplish in the way of providing overall bandwidth. It was noteworthy that, on the average, receivers built for the 525 and 625-line standards actually possess little more bandwidth than those built for the British 405-line system. This fact gives the 405-line system a considerable practical advantage over the other standards, because of an insufficiently appreciated technical fact. This is that, **for a given bandwidth,** the horizontal resolution attained actually decreases rapidly with increase in the number of lines used, once that number exceeds the figure for which the given bandwidth provides balanced horizontal and vertical resolutions. In point of fact, for example, the horizontal resolution obtained with a bandwidth of 3 mc/sec. is a maximum, at approximately 350 lines, for an actual line number of 400, and unless the bandwidth is increased as well as the

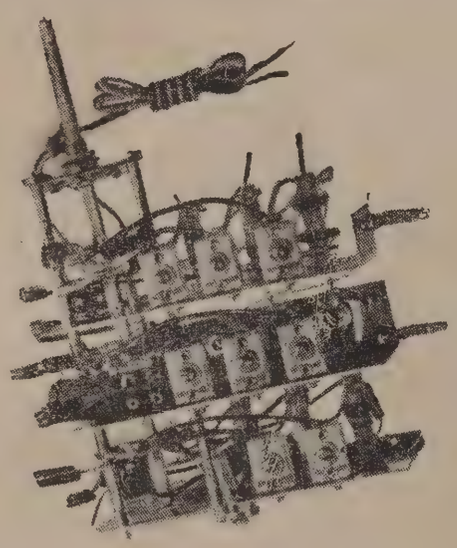
number of lines, horizontal resolution deteriorates rapidly. For instance, a 625-line system in which a receiver has a bandwidth of only 3 mc/sec. will have a horizontal resolution of only 237 lines! Put another way, a 625-line system needs a bandwidth of 4.7 mc/sec. to obtain **the same** horizontal resolution as a 405-line system with a bandwidth of 3 mc/sec.

On the economic side of the question, Mr. Palmer stated that the consensus of opinion among manufacturers everywhere was that if their sets had to have appreciably more bandwidth than they do at present, it would make a considerable difference to their selling price. He and Mr. McDonald had come to the conclusion that the 405-line system provided the best picture quality at the lowest receiver cost, so that, unless they could find any good reason for modifying it, the British 405-line system was the one they would recommend. Some American engineers, he said, were not at all sure, now, that in departing from their pre-war standard of 441 lines, they had done the right thing.

OTHER FEATURES OF THE STANDARD

Other important matters were modulation polarity and the type of sound modulation to be used. They had noticed in America, where negative modulation was used, that the picture was much more susceptible to loss of synchronism due to interference than in Britain, where positive modulation was used. On the other hand, negative modulation made it a simpler matter to provide automatic gain control in the picture channel of a receiver, and he thought that this was a major reason for the American choice in this respect. There, where several transmitters served the same area, with different radiated powers and locations, automatic gain control was very desirable, but in Britain, where a given area was served by only one transmitter, the necessity was not so great. In this respect, New Zealand was much more likely to acquire conditions approximating those in the United Kingdom, and there was no real justification for recommending a change to negative modulation.

On the sound side, there were arguments for and against FM sound, but the operative point was that the theoretical improvement over AM is realized only under the best possible conditions, in which the receiver's circuits were perfectly aligned. In practice, such conditions could be the exception rather than the rule. At the same time, an FM sound signal takes up more channel width than does AM, and even where it is used, the deviation is limited to 25 kc/sec., as against the 75 kc/sec. used in FM broadcasting. This again reduces the advantage of FM over AM.



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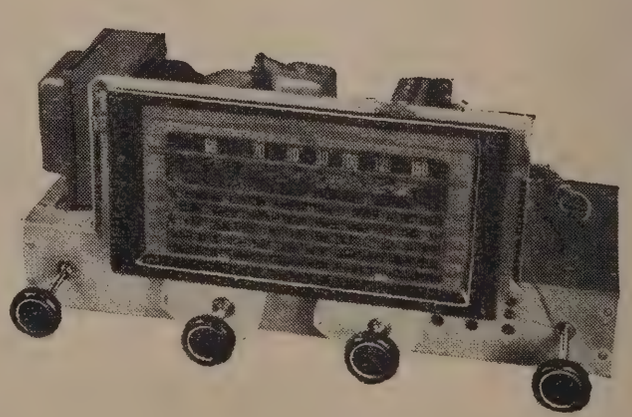

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Also, an FM sound section was more costly than an AM one in a receiver, so that unless something like the full advantage was actually obtained, it was a poorer proposition economically.

The existence of relatively different topography for the propagation of TV signals in New Zealand had caused them to recommend the following radio frequency channels:—

Auckland, 63 to 68 mc/sec.
Wellington, 48 to 53 mc/sec.
Christchurch, 58 to 63 mc/sec.
Dunedin, 53 to 58 mc/sec.

At these frequencies, the quasi-optical propagation of very high frequencies was minimized, Mr. Palmer said, and shadow effects in places like Wellington and Dunedin would be less troublesome than at higher frequencies.

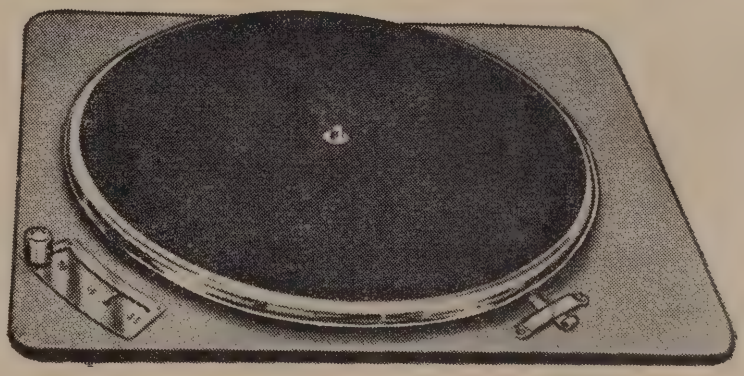
The only difference between the New Zealand recommendations and standard British practice was that, for New Zealand, horizontal polarization had been recommended. This was done on the ground that the choice cannot affect receiving installations to any extent, whereas the choice of horizontal polarization does enable high-gain transmitting arrays to be more readily used, thus effecting a considerable saving of transmitter power, or an increase in the service area for a given power. From the propagation standpoint, each had its advantages and disadvantages, and neither was markedly superior to the other.

Mr. Palmer had some very interesting observations to make concerning certain aspects of television on opposite sides of the Atlantic. For example, the British picture frequency of 25 per second enables standard 35 mm. motion picture film to be scanned at this same speed, causing only an insignificant increase in the speed of motion and in the pitch of the sound. Flying-spot scanners were used, which gave such good results that they were frequently indistinguishable from "live" telecasts. In America, on the other hand, they had to resort to the use of the ionoscope camera for scanning film because it was necessary to use a storage type of pick-up tube, which enabled them to illuminate the film twice during one frame and three times during the next, the electronic scanning taking place while the film was in darkness, and even while the pull-down was taking place. In this way, the film could be run at 24 frames a second —its standard rate—while the TV picture rate remained at the correct figure of 30 per second. On account of these difficulties, films in America gave substantially poorer quality pictures than live cameras.

As against that, it was a much simpler problem in America to produce high-quality film records of TV programmes by photographing a special display tube. In Britain, this was difficult on account of the 1 c/sec. difference between the film rate and the picture rate.

GRAWOR

Universal Three-Speed Motor (51G)



33⅓, 45, and 78 revs. per minute. Alternating current 110/220 volts, suitable for mounting in gramophones and tape recorders.

Like the modern car, the GRAWOR motor has three variable speeds to obtain 33⅓, 45, or 78 revolutions per minute. Each of these speeds is controlled by an adjustable regulating governor.

Once the controls have been adjusted, the motor is running at a constant number of revolutions, and is perfectly silent, because a milling process combined with efficient balancing of the regulating governor excludes any variation even at low speeds. The regulating governor has the special advantage in that, at top speed, the super-dimensional weights press against the cone of the brake pulley.

At 78 r.p.m. the motor has an effective output of 900 cm. per gramme—Owing to the very rigid iron sheet casing it withstands the utmost stress.—The two driving shafts are most suitable for mounting in tape recorders.—The motor has a power consumption of approximately 20 watts and, under a permanent load, becomes only a little warm, as the regulating governor acts as a fan.

***Complete with Mounting Plate*, £14 10s.**

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The total harmonic and hum content as compared with fundamental above 100 c/s is better than 34 db down (2%) at full output, and better than 40 db down (1%) at 0.1 watt.

Weight 20 lb. ***Size 13½" × 10¼" × 8¼"***

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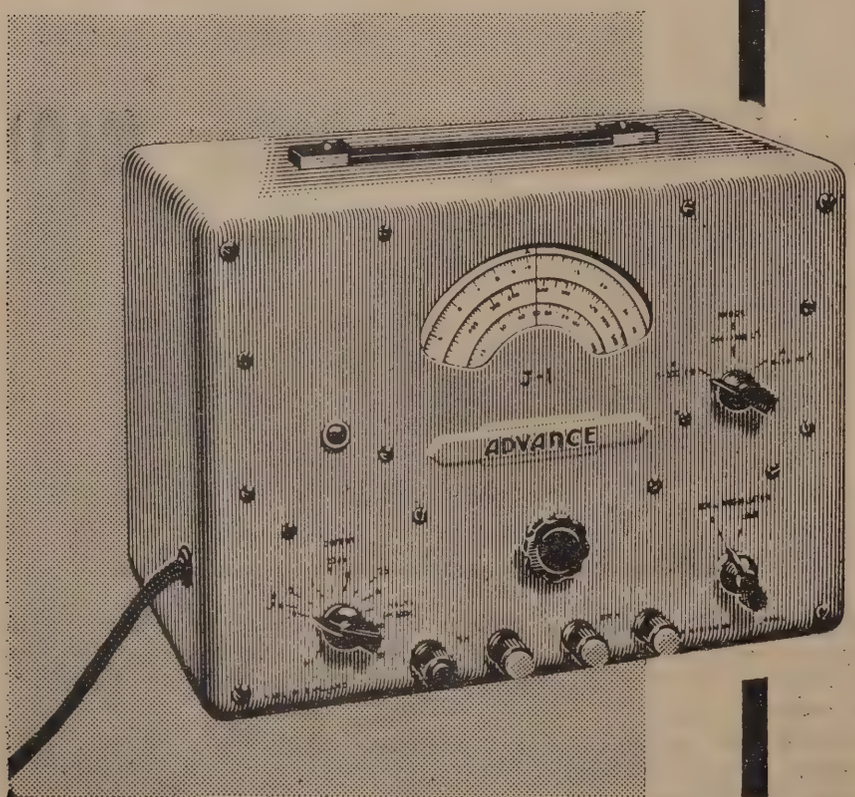

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Mechanical and Electrical Data on High-quality Pick-ups

The mechanical and electrical characteristics of gramophone pick-ups are very seldom available, and yet are of considerable interest to those technically interested in them. We therefore have much pleasure in printing the following comprehensive list, which includes all the quality pick-up heads currently available in this country, together with many that cannot yet be procured here. The explanatory list below gives the meanings of the symbols at the head of each column. We are indebted to Messrs. Green & Cooper Ltd. and to the makers of Ronette pick-ups for these data, which were measured in the Ronette factory.

Make	E 1000 N	E 1000 L	Ru	K_H 100 u	K_V 100 u	E hor. / E vert.	M 1000M	Caeq.
Ronette 284-P	0.15v.	0.04v.	120 KΩ	2.8–3.0g.	10g.	18	8–9 mg.	1500 pF
Ronette 284-P	0.18v.	0.05v.	330 KΩ	2.8–3.0g.	10g.	18	8–9 mg.	1500 pF
Ronette 284-P	0.25v.	0.065v.	500 KΩ	2.8–3.0g.	10g.	18	8–9 mg.	1500 pF
Ronette 284-O	0.7v.	0.24v.	500 KΩ	4.0g.	19g.	15	18 mg.	1500 pF
Ronette 284-O	0.35v.	0.12v.	120 KΩ	4.0g.	19g.	15	18 mg.	1500 pF
Ronette 284-O	0.55v.	0.18v.	330 KΩ	4.0g.	19g.	15	18 mg.	1500 pF
Ronette 284-N	0.24v.	0.1v.	120 KΩ	4.5–4.8g.	22g.	14	21 mg.	1500 pF
Ronette 284-N	0.45v.	0.14v.	330 KΩ	4.5–4.8g.	22g.	14	21 mg.	1500 pF
Ronette 284-N	0.6v.	0.18v.	500 KΩ	4.5–4.8g.	22g.	14	21 mg.	1500 pF
Ronette 284-B	0.8v.	0.28v.	330 KΩ	6.8–7.0g.	32g.	11	100 mg.	1500 pF
Ronette 284-B	1.1v.	0.35v.	500 KΩ	6.8–7.0g.	32g.	11	100 mg.	1500 pF
ACOS T.O. GP 29	0.7v.	0.24v.	500 KΩ	7.0g.	20g.	16	70 mg.	1200 pF
ACOS N GP 15	0.45v.		500 KΩ	6.0g.	12g.	8.3	107 mg.	1200 pF
ACOS L GP 15		0.18v.	500 KΩ	6.0g.	12g.	8.0	107 mg.	1200 pF
Astatic N U-J-78	0.13v.		500 KΩ	10g.	10g.	6	12 mg.	1000 pF
Astatic L U-J-78		0.05v.	500 KΩ	10g.	10g.	6	12 mg.	1000 pF
Garrard-Astatic 10L 3	0.8v.	0.31v.	500 KΩ	17g.	30g.	10	22 mg.	700 pF
Astatic LQD-IM	1.5v.	0.39v.	500 KΩ	14g.	40g.	16	48 mg.	1150 pF
Astatic Twin-CAC	0.46v.	0.28v.	500 KΩ	14g.	40g.	11	60 mg.	1400 pF
General EL.RPX 050	0.012v.	0.004v.	25 KΩ	9g.	20g.	18	10 mg.	Magn.
Elac L		0.30v.	500 KΩ	8g.	50g.	4	34 mg.	1000 pF
Elac N	0.9v.		500 KΩ	8g.	50g.	4	34 mg.	1000 pF
Telefunken N	0.8v.		500 KΩ	6.0g.		4.8	97 mg.	1000 pF
Telefunken L		0.22v.	500 KΩ	6.0g.		4.8	97 mg.	1000 pF
Braun T.O.	0.75v.	0.30v.	500 KΩ	9.0g.	22g.	12	18 mg.	1500 pF
Thorens	0.5v.	0.22v.	500 KΩ	5g.	7g.	8	54/96 mg.	1250 pF
Silvering	0.55v.		500 KΩ	8g.	22g.	13	12 mg.	dyn.
Luxor	0.50v.	0.18v.	500 KΩ	25g.	70–100g.	0.6	Very big.	500 pF
Aga A-2	0.65v.		500 KΩ	18g.	40g.	17	95 mg.	dyn.
Audak Comp. Audax	0.01v,	0.003v.	50 KΩ	10g.	20g.	9	13 mg.	magn.
Pickering N	0.036v.		15 KΩ	2g.	20g.	17	Cannot be measured	magn.
Pickering L		0.011v.	15 KΩ	4-6g.	20g.	17		magn.
Clarkstan RV	0.05v.		500 KΩ	50g.	80g.	3.5	Very big	magn.
Connoisseur N Sugden	0.026v.		25 KΩ	5g.	100g.	1	85 mg.	magn.
Connoisseur L Sugden		0.005v.		5g.	100g.	1	85 mg.	magn.
Walchris N	0.14v.		500 KΩ	8g.	10g.	10	41 mg.	magn.
Walchris L		0.05v.	500 KΩ	8g.	10g.	10	41 mg.	magn.
Ortofon N	0.30v.		500 KΩ	2.8g.	15g.	18	26 mg.	dyn.*
Ortofon L		0.125v.	500 KΩ	2.0g.	15g.	18	28 mg.	dyn.*

Explanation:

E 1000 N = Output voltage from Standard records at 1000 c.p.s.

E 1000 L = Output voltage from Long-playing (33⅓ r.p.m.) records at 1000 c.p.s.

R_u = Load resistance.

K_H = Horizontal displacement force (for a displacement of 0.1 mm.).

K_V = Vertical displacement force (for a displacement of 0.1 mm.).

E hor./E vert. = Ratio of horizontal to vertical output.

M 1000 M = Effectively moving mass at 1000 c.p.s.

Caeq. = Equivalent capacity of crystal cartridges.

*Matching transformers.

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Letters to the Editor

HIGH-QUALITY AUDIO

Sir.—Now that Mr. V. M. Stagpoole has finished his interesting series of articles on audio topics, I would like to comment on some of the ideas put forward. The reliance that amateurs and professional engineers place on a sine wave frequency test is no doubt due to its being simple to carry out. It is also usually sufficient to show up deficiencies in the system being tested. The frequency response, the transient response, and the phase shift of a linear system are only three different ways of expressing the same phenomenon. It can be regarded as axiomatic that a system with a flat frequency response has a good transient response. Consider the ribbon velocity microphone. A typical example has a frequency response of 40 to 15,000 cycles within one decibel, and consequently it has a good transient response. This was substantiated in 1946 by Olson and Preston, who were able to obtain square waves from a ribbon velocity microphone actuated by a loudspeaker with very smooth wide-range frequency characteristics. The fundamental resonant frequency of a mechanical transducer does not necessarily influence its transient response. If a low fundamental resonant frequency caused a poor transient response, we would expect that conventional loudspeakers would have a negligible transient response, and in this case it would be of no use worrying about what happened to transients in the preceding microphone and amplifiers. Fortunately, this is not the case, and modern loudspeakers with wide frequency ranges have correspondingly good transient responses.

We would agree that the unthinking application of negative feedback to an amplifier may produce peculiar results, but the transient response will be governed by the form of the frequency response curve obtained. If a square wave is applied to an amplifier using negative fedback, there may be an overshoot, but this overshoot is comprised of frequencies outside the frequency range of the amplifier. If the input signal to a feedback amplifier is limited to frequencies inside the range of flat frequency response, then no overshoot will be obtained.

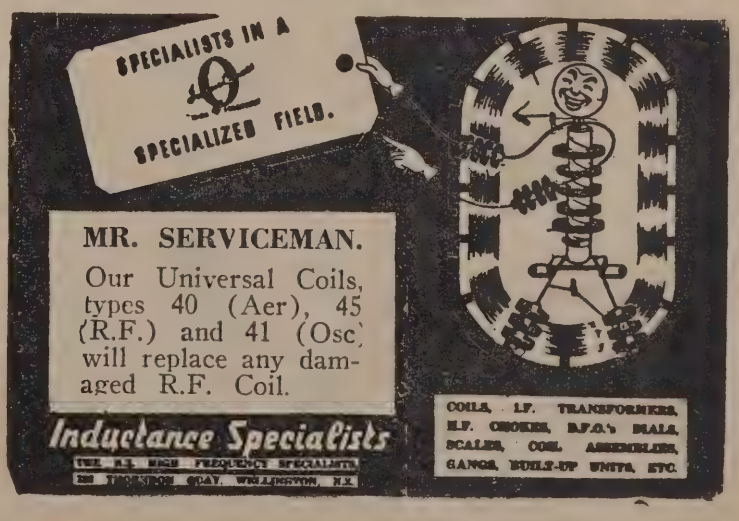
The R.J. speaker enclosure seems to be fundamentally a vented baffle with a small port having perhaps more than usual acoustical resistance. The vent resistance will have no effect on internal resonances in the box, which will be intensified by the almost cubic shape. Almost certainly better results would be obtained by lining the box with felt or similar material. However, the design seems to have no advantages over conventional vented baffles and suffers from all the disadvantages of small vented baffles. I suggest that the most reliable way of obtaining good bass response is to use a speaker with the lowest possible cone resonance and to use a vented baffle of adequate size, at least six cubic feet for a twelve-inch loudspeaker. A corner design of vented baffle is preferable, and it should be solidly constructed so as to be free of panel resonances. Internal resonances can be eliminated by the use of felt lining, and, if necessary, a felt partition at right-angles to the longest dimension.

The alleged deficiency in bass in recordings is, I think, more apparent than real. Examination of modern recordings with a magnifying glass will usually disclose heavily recorded low frequencies, although they may not be reproduced at a level lower than it was recorded at, and this produces an apparent loss of bass, as shown in the well-known Fletcher and Munson equal loudness curves for the average ear. Also, the general noise level of the average room causes considerable masking, particularly of low frequencies. Apart from the difficulties of obtaining undistorted low frequencies from loudspeakers, I find that few pick-ups produce undistorted sounds at low frequencies. All these things can contribute to producing an apparent lack of bass in reproduced music.

The general quality of L.P. records seems to come in for a good deal of criticism, but surely it is too much to expect that the average L.P. should be better than the best S.P. I think it is fair to say that the average L.P. is a good deal better than the average S.P., and the best L.P. is far superior to any shellac disc, although new problems have arisen since their introduction. Tape noises that were previously hidden by the noise level of a shellac record have now become noticeable. Also, an L.P. record imposes far more stringent requirements on the pick-up than does a wide-groove shellac record. The pre-emphasis adopted does not help matters, but satisfactory pick-ups for L.P. have been made, and the latest low-priced L.P. pick-ups are surprisingly good. Having obtained a good pick-up, I find that faults previously attributed to the recording have now disappeared, and that most L.P. records are almost faultless, while many are superb.

With reference to tone controls, I can only agree about the excellence of P. J. Baxandall's design, but would point out that he also described a simple modification which gave a different type of treble control, whereby the whole treble range is boosted or cut at intermediate settings of the potentiometer. I have found this type of control to be more suitable than those described, although this is only a matter of opinion. It would be worth while, I think, if this magazine could describe the necessary modifications. The question of continuously variable or stepped tone controls is a controversial one, but, personally, I have found the original Baxandall circuit to be very satisfactory. It is also cheaper than the stepped type of control.—I am, etc.,

M. E. PATTINSON.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INTRODUCTION

Ordinary resistors and condensers are usually regarded as having a constant or fixed value equal to that marked or coded on them, and for most purposes it does no harm to think of them in this way. However, their values are not fixed, but are affected by a number of outside influences, of which temperature is one of the most commonly encountered. All pure metals, and almost all synthetic materials used for making resistors have what is known as a positive temperature coefficient. This means simply that if the temperature of a material is raised, its electrical resistance increases. Conversely, of course, its resistance will decrease if the temperature falls. Most of the uses which the electronic or radio engineer finds for resistors are not particularly critical as to the exact values of the resistances, so that we are very often able to ignore the effect of temperature. For example, when a resistor is used as a grid leak in a Class A amplifier, it is of almost no concern to us whether its value is 0.5 megohms, or 0.6. This fact is brought home when it is remembered that in radio receivers and amplifiers we very rarely have to specify the resistance of the resistors more accurately than to within 20 per cent. of their nominal value. In measuring instruments, on the other hand, and particularly when any sort of accuracy is required, resistors used in the measuring circuits must have their values known within very much closer limits; at the same time, outside influences such as temperature must not be able to affect the resistances so much that the accuracy of measurement is impaired. In such cases, it is often essential to ensure that the resistors have a very small temperature coefficient. It is for this reason that special alloys have been developed, which have very much smaller temperature coefficients than others, however, useful their other properties may be. It seems to be one of Nature's laws that pure metals have a positive temperature coefficient. One possible method of making resistors whose value does not change with temperature is to take an ordinary resistor, somewhat higher in value than is required, and place in parallel with it another resistor with a **negative** temperature coefficient. That is to say, one whose value **decreases** with increasing temperature. Then, by correctly choosing the values of the two resistors and their respective temperature coefficients, we can arrange things so that the composite resistor's value does not change, whatever the temperature does. This is the most obvious application for resistors with negative temperature coefficients, and a very useful one, too, but it is only comparatively recently that such resistors were developed in the Philips laboratories, and in others. The difficulty was to find a material which not only had a negative coefficient, but which had stable characteristics. In all other respects, a material suitable for this application must be similar to ordinary resistive materials. For instance, unless the material always has the same resistance at the same temperature, it will clearly be of very little use, since it would not be possible to predict its resistance under a given set of conditions.

As often happens when something new is developed for a specific application, its new properties are put to a wide variety of uses which were never even thought of at the outset. Such has been the case with Philips NTC resistors, as they have been named, and this article is intended to illustrate some of the many interesting and useful jobs that NTC resistors can do.

THREE BASIC APPLICATIONS

Fundamentally, NTC resistors can be used for three purposes. The first, that of compensation, we have already described briefly. The other two are measuring and regulating. These two are closely allied, since any regulating mechanism can be regarded as possessing two parts—a measuring or sampling system, and a control system.

In the measuring field, NTC resistors find application to any problem in which the effect to be measured can be converted into a temperature variation. Thus, all such measurements become either a measurement of temperature, with the NTC resistor used as a thermometer, or a measurement of the rate at which temperature varies.

First of all, let us see how an NTC resistor can be used as a thermometer. It is possible to imagine the resistor placed in the position where the temperature is to be measured, and connected to a direct-reading ohm-meter circuit, calibrated in degrees instead of in ohms. In this and similar applications, it should be pointed out that the NTC resistor is useful not because its temperature coefficient is negative, but because it is so large, being from eight to twelve times that of the best metallic resistor that has been made for a similar purpose.

A thermometer built along the lines suggested, however, would not be very satisfactory, since the common ohm-meter circuit is inherently a somewhat inaccurate measurer of resistance. It would also have a very cramped and awkward scale to read, except at certain temperatures, so that for simple reading of temperature, such a device would not be likely to

compete seriously with the ordinary mercury thermometer. For the majority of industrial or scientific purposes, however, we are interested in the accurate measurement of temperature round about a certain value. A typical example of this would be measuring the temperature inside a cool store, where a range of a few degrees on either side of the desired temperature is all that is necessary. This is a particularly good example, because the characteristics of the NTC resistors are such that their sensitivity is greatest at low temperatures.

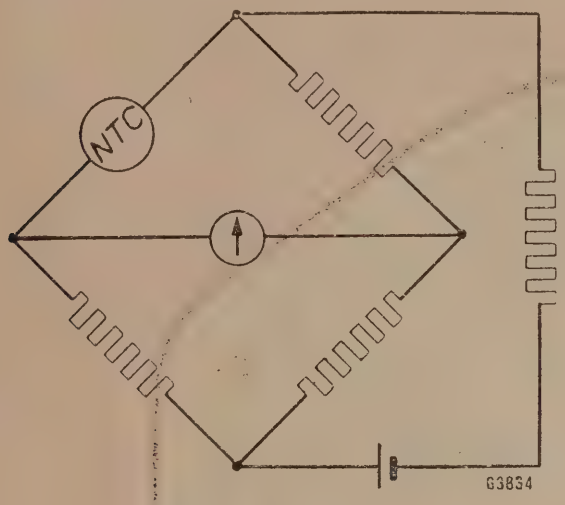

Fig. 1.

Another advantage of NTC resistors for measuring temperature is that they can readily be made in small physical sizes, but with high values of resistance. This makes it possible to locate the NTC resistor at a great distance from the rest of the measuring circuit, thereby obtaining accurate remote indication. The importance of a high-resistance can be very much greater than that of the wires connecting it to the rest of the circuit, so that variation in the resistance of the wires has only a negligible effect on the measurement. The resistors are so small that they enable temperature measurements to be made in places that would be quite inaccessible to other measuring devices. Examples of this are the measurement of the temperature of cooling liquids in various points of an internal combustion engine, or in measuring the temperature of a bearing.

The commonest and most accurate method of using the NTC resistor is to use it as one arm of a Wheatstone bridge, as shown in Fig. 1. The circuit can be so adjusted that, at the required temperature, the bridge is balanced. Then, any variation of temperature is indicated by a change of reading of the meter, which is preferably of the centre-zero type. Such a circuit can have an almost linear scale, and by the design of the circuits associated with it can be arranged to have any desired degree of sensitivity. One cause of inaccuracy in such measurements is the variation in resistance of the resistor in the same side of the bridge as the NTC resistor. Everything in the circuit except the NTC resistor is at room temperature, but, as this varies, so will the values of the bridge resistors. The greater part of the inaccuracy due to this variation may be removed by the simple expedient of replacing one resistor with a second NTC resistor, identical with the measuring one. Thus, any changes in the balance-point of the bridge due to variations in the ambient temperature will be compensated.

For applications where extreme accuracy is wanted, an NTC resistor can be used as one of the frequency-determining elements of an RC type of audio oscillator. Variations of temperature then cause corresponding variations in the oscillation frequency, which can be measured with very great accuracy. This method has the advantage that the tone can be transmitted by radio, and since its frequency will not be affected by the characteristics of the transmission

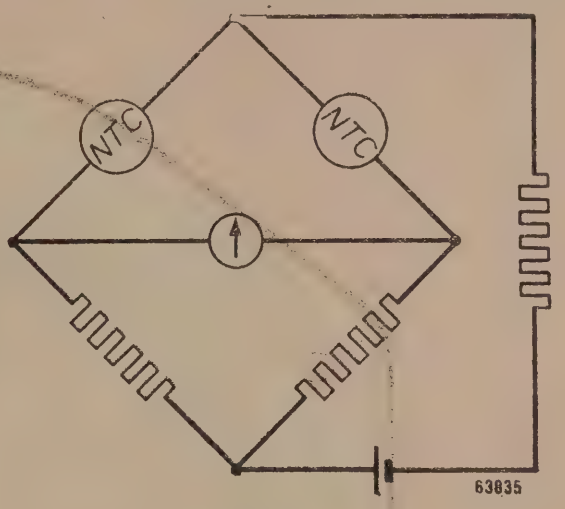

Fig. 2.

path, or by those of the transmitter or receiver, none of these factors will influence the accuracy of the results.

Given the NTC resistor as a sensitive indicator of temperature differences, it is possible to use them in the design of thermostats, or temperature controlling devices. In this case, a bridge circuit can be used, similar to those of Fig. 1 or Fig. 2, but with the meter replaced by the grid circuit of a D.C. amplifier valve, in whose plate circuit is a relay. The latter can thus be arranged to close at a certain temperature, turning on the heater which is being controlled, and to open again when another specified temperature is reached, turning off the heater. In this way, the temperature of the place in which the NTC resistor and heater are situated can be regulated to almost any required degree, dependent only upon the design of the regulating circuits.

PROBLEMS INVOLVING THE FLOW OF LIQUIDS OR GASES

A flow-meter can be made by taking advantage of the fact that a flow of liquid or gas will carry off heat from an NTC resistor at a rate which is dependent on the rate of flow. Thus, if an NTC resistor bridge like that of Fig. 2 is set up, with both resistors in the gas or liquid, but only one of them in the flow, this one will lose the heat more rapidly than the other, and the current in the indicator can be calibrated in terms of the rate of flow. The reading will be independent of the temperature of the liquid or gas, provided it is uniform at all points. Another obvious application of the differential cooling of two NTC resistors in a bridge circuit is to the

(Continued on page 33.)

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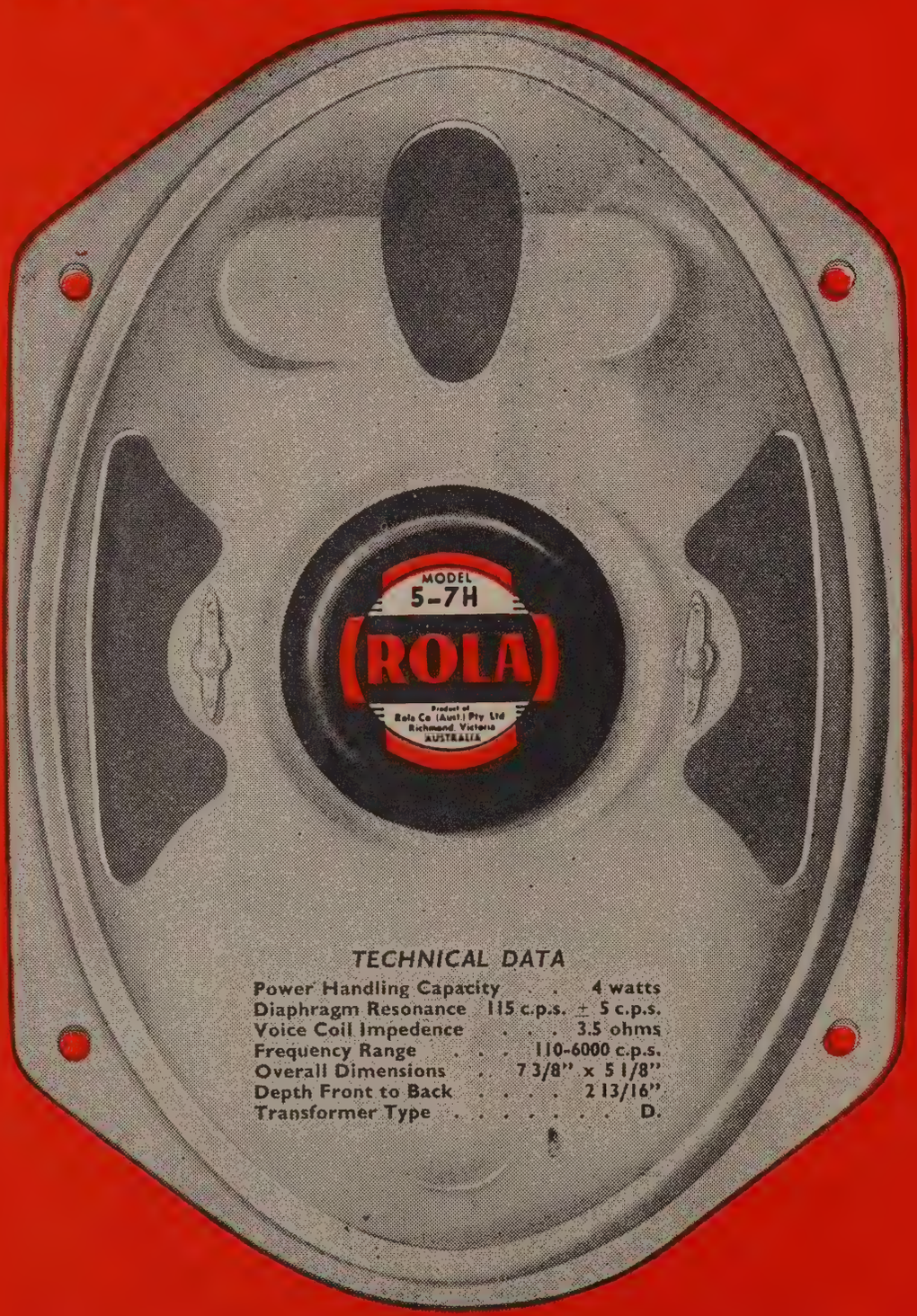


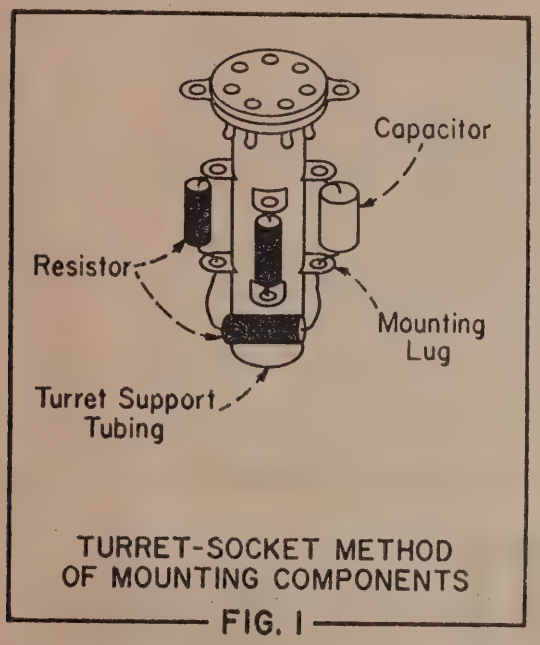
TECHNICAL DATA

Power Handling Capacity	4 watts
Diaphragm Resonance	115 c.p.s. ± 5 c.p.s.
Voice Coil Impedence	3.5 ohms
Frequency Range	110-6000 c.p.s.
Overall Dimensions	7 3/8" x 5 1/8"
Depth Front to Back	2 13/16"
Transformer Type	D.

Simplified Subminiature Assemblies for Experimenters

By the Engineering Department, Aerovox Corporation

Subminiature electronic components of many types now are available. Aside from transistors, there are tiny vacuum tubes, capacitors, resistors, crystal diodes, transformers, potentiometers, rotary selector switches, pilot lamps, coils, chokes, meters, and batteries, all obtainable at any well-stocked parts distributor.



TURRET-SOCKET METHOD OF MOUNTING COMPONENTS

FIG. 1

Availability of these parts will enable the experimenter to miniaturize various pieces of his equipment. In addition, there is the intriguing challenge to create new equipment of the personal-portable type. But the average hobbyist who has concentrated on the conventional chassis-and-panel type of electronic construction discovers considerable personal clumsiness and lack of mechanical ingenuity when first attempting to work with subminiature components. This article will explain how simple assemblies may be made using these parts. Its purpose is to show how to do a satisfactory job without special tools.

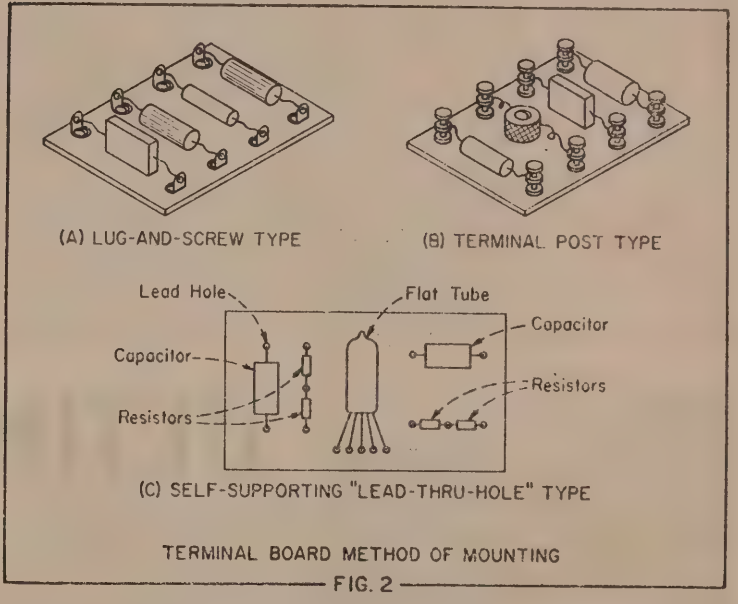
TURRET SOCKETS

One of the simplest devices for compact miniature construction is the turret-type tube socket, also called a socket turret. As shown in Fig. 1, there is attached under this socket a short length of insulating tubing (the "turret") around which mounting lugs are fastened. Circuit components may be attached by means of their pigtail leads between these lugs and from lugs to the socket contacts. Complete amplifier, oscillator, and control circuits may be assembled around a tube in this fashion, and can be installed or removed as units. The only external connections required are for the operating voltages and coupling between stages. Socket turrets are available in miniature, as well as octal, types. While the socket turret is not a true subminiature component, its small size and the compactness it provides aid materially in reducing the dimensions of equipment which normally is spread over and under a chassis.

TERMINAL BOARDS

The small terminal board is a simple and straightforward supporting medium for circuit components in subminiature assemblies. Complete stages and circuits, as well, including small supply batteries, can be assembled on small boards or cards of this type. This type of construction often is employed in hearing aids, test instruments, pocket radio receivers, and similar devices which do not employ printed circuits.

Figure 2 shows three representative types of terminal boards which can be made easily by the experimenter. Each uses a thin sheet of bakelite or fibre as the board. The first unit (Fig. 2A) employs ordi-



TERMINAL BOARD METHOD OF MOUNTING

FIG. 2

nary soldering lugs for terminals, and these are held in place by short machine screws and nuts. The lugs also could be riveted in place, but most experimenters do not have the tools or machines to do this job.

Figure 2 (B) shows a board made up with the popular turret-type pin terminals of the CTC (Cambridge Thermionic) and USES (United States Engineering) types. Advantages of this style of terminal are its smaller size, rigidity, and provision in each terminal pin of several grooves for attaching separate pigtails. In general, it is easier to tie leads to and remove them from the turret terminal pins than from lugs. Turret-type terminal boards are available ready-made in several sizes and with various numbers of pins. The pins can be bought separately and fastened to an individual terminal board with simple tools.

The board shown in Fig. 2 (C) eliminates all lugs, pins, and other terminals, substituting pin-holes through which the pigtail leads of the components are passed and drawn tightly. On the other side of the board, the leads may be interconnected, as required by the circuit, or attached to those of other components. This type of construction provides mechanical support for the components, as well as permitting a direct and easy method of wiring the circuit. Elimination of the protruding terminals usually found on a terminal board further reduces the space and weight totals of the assembly. Using the "pin-hole" terminal board, it is possible to build an entire unit of equip-

ment (including several stages) using only the pigtails of components for mounting and wiring. It is possible at the same time to obtain a tight construction. Single-end-mounted components, such as subminiature tubes, may be tied down by means of strap-clamps or clips.

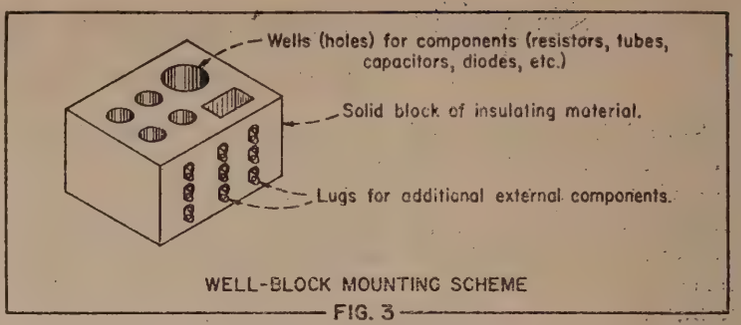
Components may be mounted on both sides of any type of terminal board. The pins or lug-screws then may be utilized to carry connections through the board, or the leads themselves passing through the pin-hole board may be attached directly to those of components on the reverse side of the board.

Board-assembled circuits subsequently may be encased or may be potted as will be described later in this article.

The board-type subminiature assembly is compact and usually represents the smallest size and lightest weight attainable in a particular construction, short of printed circuitry. It has the slight disadvantage, however, that components sometimes are not easily removable by unsoldering when replacements must be made. This is true particularly of the pinhole-type board and to a lesser extent of those boards using pins or lugs.

WELL-BLOCK HOUSING

The mounting shown in Fig. 3 is a solid block of some insulant, such as bakelite or other plastic, with holes or "wells" cut to hold capacitors, resistors, and


Wells (holes) for components (resistors, tubes, capacitors, diodes, etc.)
Solid block of insulating material.
Lugs for additional external components.

WELL-BLOCK MOUNTING SCHEME
FIG. 3

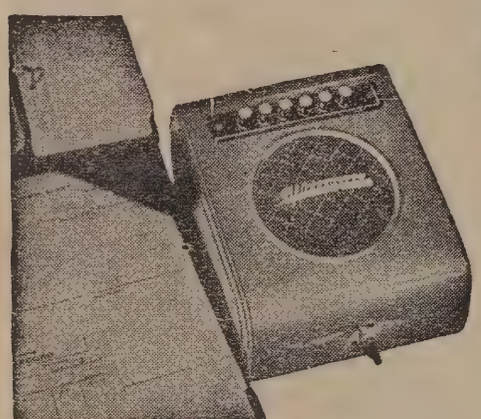
other components. Lugs are attached also to the sides of the block for the attachment of external components. Well-blocks of this sort are used in some multimeters to contain the multiplier and shunt resistors.

After wiring is completed, panels may be attached to the top and bottom of the structure to enclose the components completely.

The well-block has the advantages of solidity and rigidity. However, components, such as heated tubes and resistors, which require the free circulation of air for cooling, cannot be placed in the wells.

COMPONENT COMBINATION

Component combination refers to associating two or more components intimately in a mechanical con-



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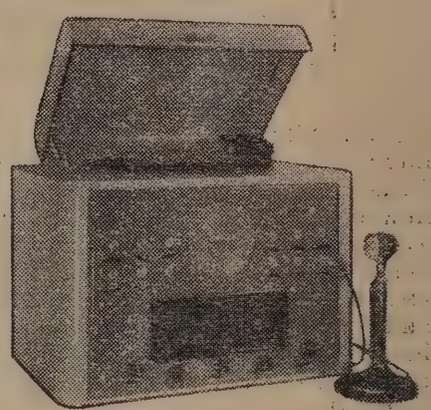

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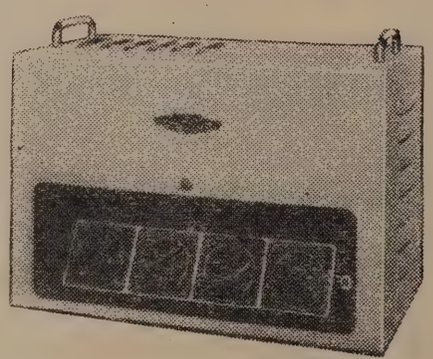

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struction, in order to conserve space. Examples are: a coil wound on the insulating body of a resistor, a trimmer capacitor mounted inside a coil form, a coil wound around the glass envelope of a vacuum tube, and a shunt resistance element painted on the bakelite case of a capacitor. This technique is an invaluable aid to subminiaturization when it does not degrade the electrical performance of the circuit.

Whether component combination can be employed successfully depends upon the pertinent factors in an individual case. For example, the Q of a coil is lowered by conducting components within its field. Thus, the advisability of mounting a trimmer capacitor inside a coil form depends upon how much Q reduction can be tolerated in the coil. The same applies to a resistor made to function as a coil form. A coil wound on the glass envelope of a vacuum tube might have its characteristics altered not only by the presence of the metallic electrodes of the tube within its magnetic field but also by heating from the tube.

Before undertaking component combination, it is advisable to make actual tests of the effects upon electrical characteristics of one component by the proximity of the other. In this way, the feasibility of the combination may be established, or a more efficient way of mechanically combining the components devised.

Aside from the chance of altering electrical characteristics (principally capacitance, inductance, and Q) in combining components, the greatest interference perhaps arises from heat. A coil- capacitor, diode, transistor, or thermistor will, unless it is suitably temperature-compensated, exhibit instability when closely associated with a hot resistor or tube. And the addition of correct compensating devices often defeats the original purpose of size reduction.

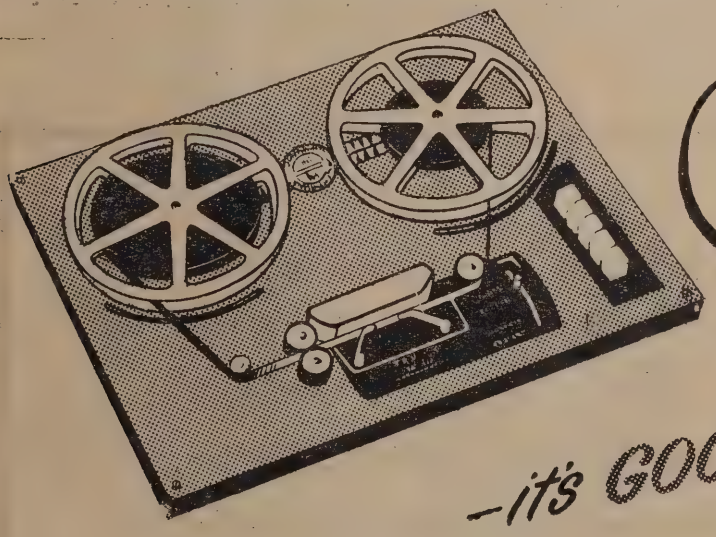
POTTING MINIATURE CIRCUITS

A technique which has found wide acceptance in commercial subminiaturization is that of potting. This refers to the practice of casting the component assemblies into a solid block or capsule of insulating material. The end result is a compact, neat, and rigid assembly which resists mechanical and electrical disturbance. Large-scale potting of subminiature circuitry is found in the radar and guided-missile fields.

There are many materials and methods of potting. Some are older than radio itself, but have been employed for some time. Well-known examples are the potting in waxes of transformers, chokes, capacitors, and similar components.

Although casting of multiple components has many advantages, its full usage in the electronic industry is retarded by certain drawbacks. These include the additional weight, higher cost, and the fact that the failure of one potted component necessitates the discarding of the entire cast assembly.

The modern media for potting subminiature electronic circuits are "polymerizing" synthetic resins



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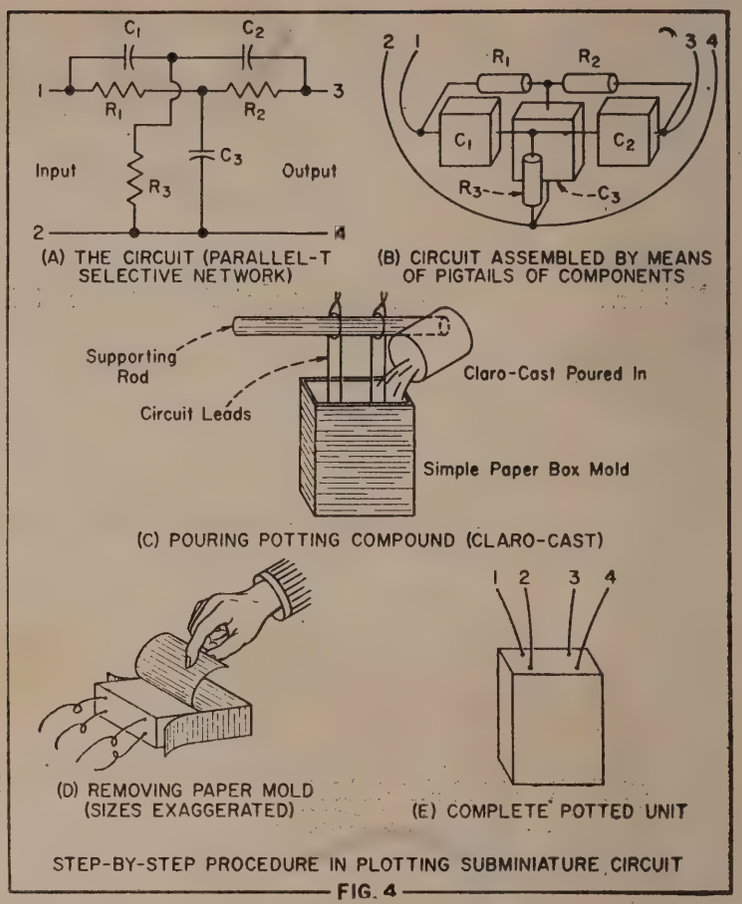
which "cure" from a liquid to a rigid solid with or without the application of cast.

There are many casting materials (aside from coil dope, which does not set up quickly and satisfactorily) which can be handled by the amateur. A popular one in the electronic industry is an epoxy type casting resin which sets up at resin temperature after it has been mixed with a "hardener." Another one which is easy to use in the small shop is a polyester type resin which "cures" in a similar manner. While this material is used extensively by hobbyists for the mounting of flowers, insects, coins, medals, etc., it also has good electrical characteristics and can thus be used successfully for electronic potting.

Figure 4 illustrates typical steps in assembling a miniature electronic circuit and imbedding it in a block of polyester resin. A parallel-T selective R-C network has been selected for illustration.

Figure 4 (A) shows the circuit, and 4 (B) the components assembled by the direct connections together of their pigtail leads. The assembly then is hung in a mould made of a small paper box. The inside of this box must be lightly coated with furniture wax or soap. The hanging is shown in Fig. 4 (C).

The casting material is prepared in the following manner: Work outdoors or in a well-ventilated room. Measure out the amount of resin liquid required with a tablespoon. Add one drop of the supplied hardener for each tablespoon of resin. Stir the mixture thoroughly, allow to stand for five to ten minutes, and break any bubbles with a straw or long toothpick. Pour the mixture into the mould slowly, avoiding bubble formation. The mixture will thicken and jell.



STEP-BY-STEP PROCEDURE IN PLOTTING SUBMINIATURE CIRCUIT

FIG. 4

(Continued on page 48.)

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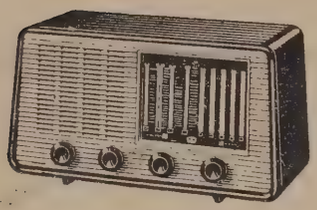

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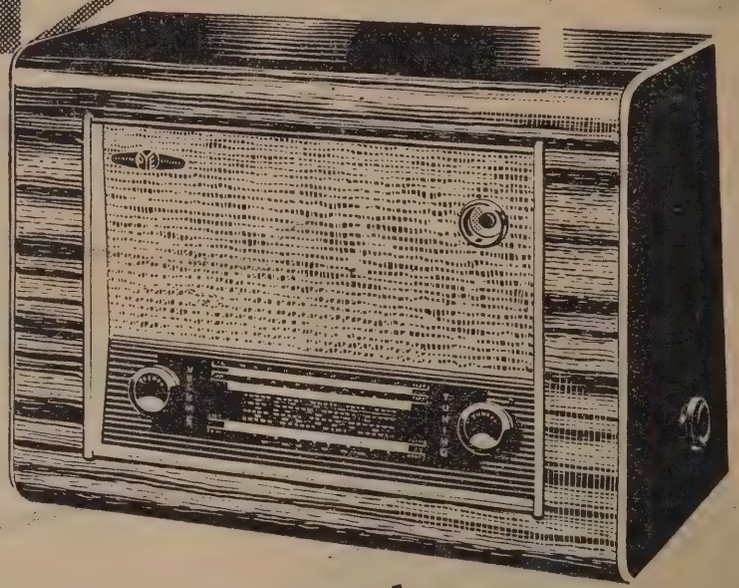

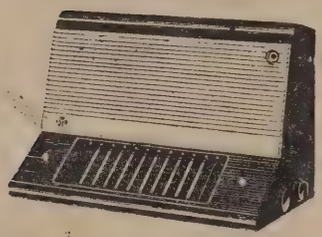

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(Continued from page 25.)

measurement of the relative humidity of the atmosphere, by means of the wet-and-dry bulb thermometer technique. Here the two thermometers would be replaced by NTC resistors, and by making the bridge unbalance operate a pen recorder, a recording instrument can be devised.

SOME ELECTRICAL APPLICATIONS

While all the applications listed above employ an electrical circuit, they are not really electrical applications of NTC resistors, in the sense that they are applied to electrical problems.

Some electrical applications are:

(1) The measurement of R.F. power.
(2) Current limiting.
(3) Time-delay switches.
(4) Contactless switching.
(5) Automatic volume (or gain) control.

For measuring small amounts of R.F. energy, especially at very high frequencies, the NTC resistor can be used as a bolometer. Here again the resistor is made part of a D.C. or low-frequency A.C. bridge circuit, which is balanced in the absence of any R.F. power. At the same time, however, the resistor is connected as the load for the device producing the R.F. energy. Then, when the latter is turned on, the resistor is heated, its value changes, and the bridge becomes unbalanced. Then, by changing the amount of D.C. fed to the bridge, the latter again becomes balanced, and the amount of D.C. energy subtracted is measured. This must be equal to the amount added to the NTC resistor by the R.F. when it is turned on. Chokes prevent the R.F. from entering the D.C. resistance-measuring circuit, and as long as the D.C. power passed through the NTC resistor by the ohmmeter is very much less than the resistance to be measured, the accuracy will be substantially that of the ohm-meter. The whole thing is calibrated by drawing a curve showing the power dissipated, against the resistance of the NTC resistor. Then, to take a reading of R.F. power, one measures the resistance with the ohm-meter, and then applies the answer to the graph.

For current limiting, NTC resistors are very effective. The heaters of valves have a very large positive temperature coefficient, so that when current is first switched on, there is an initial surge of many times the nominal current. By connecting an NTC resistor in series with the heater chain, it can be arranged that the initial resistance is approximately the same as the hot resistance, so that the NTC resistor compensates almost exactly for the increase in resistance of the filament chain.

A simple application to time-delaying is the connection of an NTC resistor in series with a relay. The operating voltage is applied to the combination of relay and NTC resistor in series, but at first, owing to the high resistance of the latter when cold, insufficient current flows to close the relay. After a time, however, the small current through the circuit heats the NTC resistor, lowering its resistance, and allowing enough current to flow to close the relay. The amount of the delay depends on the time taken for the resistor to reach thermal equilibrium with its surroundings, and so can be lengthened by such artifices as enclosing the resistor in a block of copper. In this way, delays of up to 15 minutes can be arranged. It can be seen that NTC resistors provide a very simple means of delaying the application of H.T. voltage to a valve until its filament has been heated for a stated length of time.

The property of NTC resistors which makes it possible to use one as a kind of contactless switch is as follows. When voltage is applied across an NTC resistor, there is a certain minimum, or threshold, voltage, below which the current through the resistor is insufficient to cause the usual large drop in resistance to take place. Thus, if the voltage across the circuit containing the NTC resistor is below the threshold value, only a small current flows. As soon as the threshold value is exceeded, however, the resistance decreases rapidly, causing a much larger current to flow. The resistor thus simulates the action of a switch.

For automatic gain control in amplifiers and oscillators, the NTC resistor is much more satisfactory than the positive-temperature-coefficient devices, such as small tungsten-filament lamps, that are so commonly used. The reason for their superiority is to be found in the fact that their ratio of maximum to minimum resistance is so much higher than that of a lamp. Because the temperature coefficient is negative, however, the NTC resistor cannot be used in the same position in a circuit as a lamp, but this

(Continued on page 48.)

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Malaguena (Lecuona) and La Comparsa (Lecuona) with chorus: Semprini (Pianoforte) with Rhythm Accompaniment (B10470 HMV).

Fantasia Impromptu in C Sharp Minor, Op. 66 (Posth.) (Chopin), and Intermezzo in B Flat Minor, Op. 117, No. 2 (Brahms): Moura Lympany (Pianoforte) (C4209 HMV).

Havanaise, Op. 83 (Saint-Saens), 2 Parts: Jascha Heifetz (Violin) and the R.C.A. Victor Symphony Orchestra conducted by William Steinberg (DB21552 HMV).

Sonata in E, L23 (Scarlatti) and Sonata in D, L413 (Scarlatti): Dinu Lipatti (Piano) (LB113 Columbia).

Polonaise No. 2 in E Flat Minor (Chopin (Op. 26): Malcuzynski (Pianoforte) (LX1416 Columbia).

Etudes d'Execution Transcendente (Liapounov)—No. 1 in F Sharp, No. 2 in D Sharp Minor, No. 3 in B Major, No. 4 in G Sharp Minor, No. 5 in E Major, No. 6 in C Sharp Minor, No. 7 in A Major, No. 8 in F Sharp Minor, No. 9 in D Major, No. 10 in B Minor, No. 11 in G Major, No. 12 in E Minor: Louis Kentner (Pianoforte) (LX8822/8830 Columbia).

Orchestral

Overture, The Wasps (Vaughan Williams), Parts 1 and 2: London Symphony Orchestra conducted by Herbert Menzies (C4195 HMV).

Porgy and Bess, Selections 1 and 2—Intro; Summertime; I Got Plenty o' Nuttin'; Bess, You is My Woman; It Ain't Necessarily So; A Woman is a Sometime Thing; There's a Boat Dat's Leavin' Soon for New York; Bess You is My Woman: The Melachrino Orchestra conducted by George Melachrino (C4211 HMV).

Morning, Noon, and Night in Vienna Overture (Suppe) (2 Parts): Sir Thomas Beecham, Bart., conducting the Royal Philharmonic Orchestra (LX1438 Columbia).

Rhapsody for Orchestra (A. Schnabel) (4 sides): Philharmonic Orchestra (LX8843/8844 Columbia).

Light Opera

The Starlings and A Quiet Stroll: Charles Williams and His Concert Orchestra (DB3215 Columbia).

Henry VIII Dances (German)—No. 1, Morris Dance; No. 2, Shepherds' Dance (Part 1); No. 2, Shepherds' Dance (Conclusion); No. 3, Torch Dance: George Weldon conducting the London Symphony Orchestra (DB3217 Columbia).

Magic Circles and Cornflakes: Sydney Torch and His Orchestra (R3691 Parlophone).

Vocal

Canto Della Solitudine and Lasciami Cantare Una Canzone: Luciano Virgili (Tenor), with Orchestra (JOM70 HMV).

Giulio Cesare—Alma Del Grand Pompeo (Caesar's Aria, Act 1 (Handel-Haym), sung in Italian; Messiah (Part 1)—Air, O Thou That Tellest (No. 9) (Handel): Alfred Deller (Counter-Tenor) and the Philharmonic Orchestra conducted by George Weldon (C4222 HMV).

Mama Mia, Che Vo' Sape (My Mother Wants to Know) (Russo-Nutile, arr. Burger); Senza Nisciumo (Alone) Barbieri—E de Curtis (arr. Burger) (both in Italian): Ferruccio Tagliavini (Tenor) and the R.V.A. Victor Orchestra conducted by Renato Cellini (DA2029 HMV).

Il Barbiere Di Siviglia (Act 1) Cavatina; Una Voce Poce Fa (Through His Voice was Breathed Afar); Io Sono Docile (On Me Should Kindly Love) (Rossini-Sterbini) (both in Italian): Victoria De Los Angeles (Soprano) and the Milan Symphony Orchestra conducted by Tullio Serafin (DA 2030 HMV).

Der Erlkonig, Op. 1 (Goethe-Schubert); Die Beiden Grenadiere from Romanzen Und Balladen, Op. 49, Vol. 2, No. 1 (Heine-Schumann): Dietrich Fisher-Dieskau (Baritone), in German, and Gerald Moore (Pianoforte) (DB21350 HMV).

Aida (Act 1) Sequel Guerrier Io Fossi (What if 'tis I Am Chosen); Celeste Aida (Heav'nly Aida) (Verdi-Ghislanzoni); La Gioconda (Act 2), Cielo E Mare! (Heaven and Ocean) (Bonchielli-Boito) (sung in Italian): Jussi Bjorling (Tenor) and the R.C.A. Victor Orchestra conducted by Renato Cellini (DB21563 HMV).

Marta—M'Appari Tutt' Amor (My Raptured Gaze Since First Enchanting (Act 3) (Flotow-De Lauzires-Riese); La Traviata—Brindisi: Libiamo, Libiamo Ne' Lieti Calici (Where Beauty and Mirth are Beckoning) (Act 1) (Verdi-Piave) (with Elaine Malbin, Soprano, and Chorus; sung in Italian): Mario Lanza (Tenor), with R.C.A. Victor Orchestra conducted by Constantine Callinicos (DB21571 HMV).

Long Live Elizabeth; Yeomen of England (Soloist, Frederick Harvey (both from "Merrie England" (Hood-German): Charles Williams and His Concert Orchestra and Chorus (DX1868 Columbia).

Medtner Songs—Rose; When Roses Fade; In Vorubergehen; Elfenliedchen; Meeresstile; Gluck-lichefahrt; Die Quelle; Selbsbetrug; The Muse; So Tanzet; Waltz; Einsamkeit; Praeludium Winternacht: Elizabeth Schwartskopf (Soprano) and Gerald Moore (Pianoforte) (LX1423, 1424, 1425, 1426 Columbia).

Der Fliegende Hollander (Wagner); Sentas Ballad, Act 2, Jo-Hoe-Hoe!; Doch, Dass Der Arme (Yet Did God's Angel) (sung in German): Leonie Rysanek (Soprano), with the Philharmonic Orchestra conducted by Wilhelm Schuechter, with chorus of the Royal Opera House, Covent Garden (LX1573 Columbia).

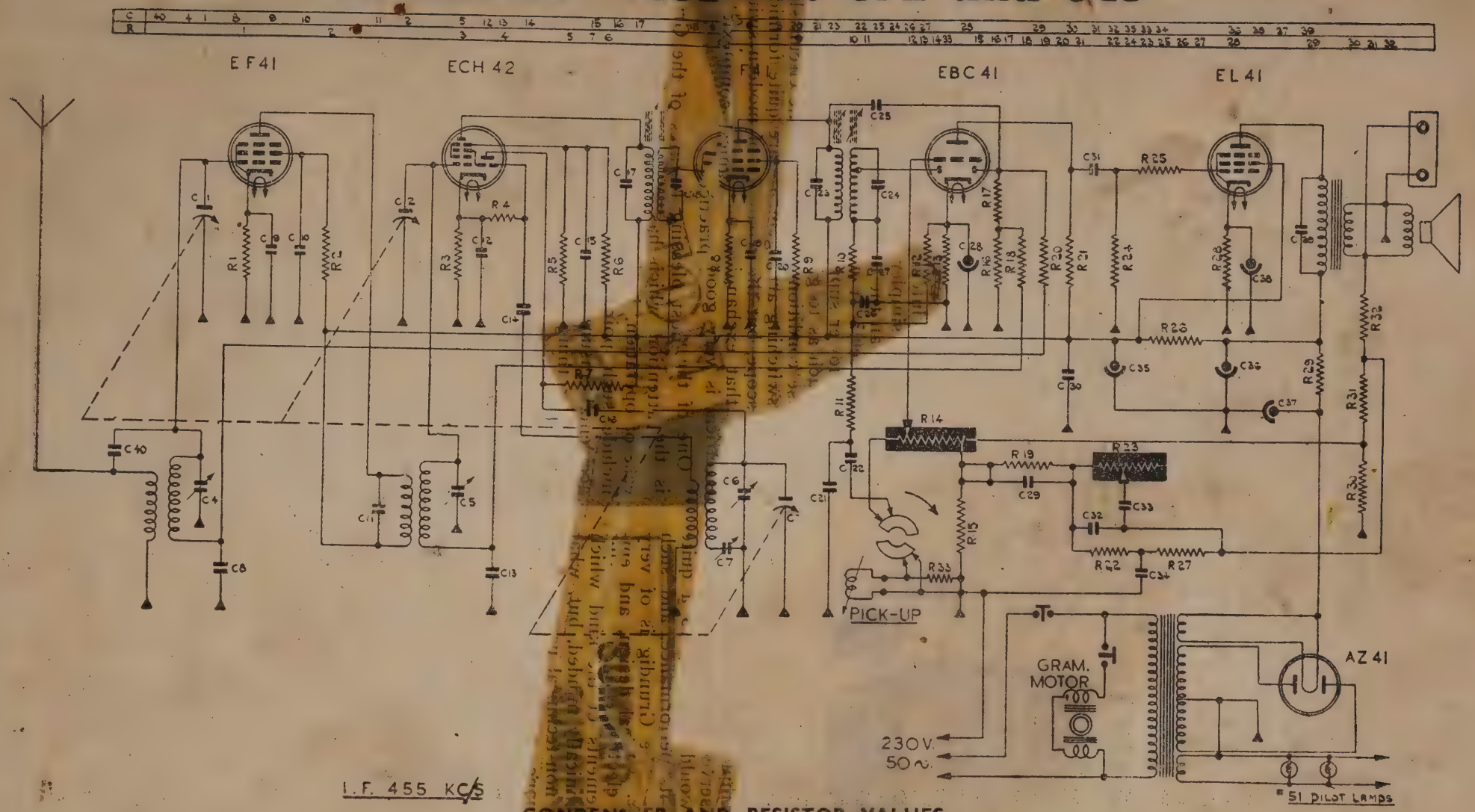
Papaveri E Papere—Ritmo Allegro; Due Gattini—Moderato: Nilla Pizzi E Coro Orchestra Della Canzone. Duo Fasano Orchestra Della Consone (both sides in Italian) (DP318 Parlophone).

Am Himmel Zieh'n Die Wolken In Die Ferne; Ich Warte, Ich Warte Auf Dich: Magda Hain (Soprano with Orchestra (sung in German) (DPW33 Parlophone).

Coronation Anthem: Let Thy Hand Be Strengthened (Handel) 2 Parts: Chorus and Chamber Orchestra of the Danish State Radio conducted by Mogens Woldike (by arrangement with the Haydn Society Inc., Boston, Massachusetts (R20620 Parlophone).

Il Barbiere Di Siviglia (Rossini-Sterbini), Act 1, La Calunnia (O, A Whisper); Simon Boccanegra (Verdi-Piave-Boito), Prologue—A Te L'Estremo Addio Il Lacerato Spirito (with Chorus) (both in Italian): Giulio Neri (Bass) with Orchestra, Sinfonica Di Torino Dell Radio Italiano conducted by Arturo Basile (R30051 Parlophone).

MULLARD—MODELS 672 and 643*



I.F. 455 KC/S

CONDENSER AND RESISTOR VALUES

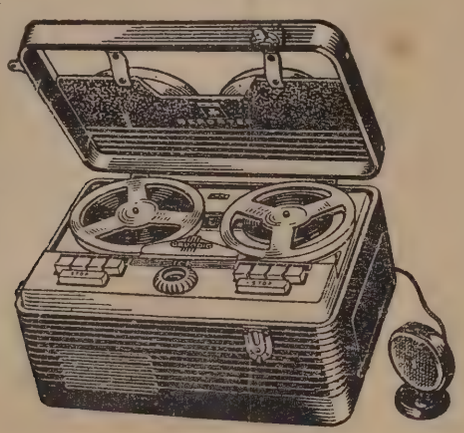
C1	} Gang tuning condenser
C2	} 13—438 mmfd.
C3	}
C4	} Air trimmers
C5	} 3—30 mmfd.
C6	}
C7	B.C. padder 150—170 mmfd.
C8	.05 mfd. 400v. paper
C9	.05 mfd. 400v. paper
C10	.01 mfd. 400v. paper
C11	100 mmfd. ceramic
C12	.05 mfd. 400v. paper
C13	.05 mfd. 400v. paper
C14	56 mmfd. ceramic
C15	.01 mfd. 400v. paper
C16	150 mmfd. ceramic
C17	I.F. trimmer
C18	I.F. trimmer
C19	.05 mfd. 400v. paper
C20	.01 mfd. 400v. paper
C21	100 mmfd. ceramic
C22	.01 mfd. 500v. minicap
C23	I.F. trimmer
C24	I.F. trimmer
C25	10 mmfd. ceramic
C26	100 mmfd. } diode filter
C27	100 mmfd. } diode filter
C28	25 mfd. 25v. electrolytic
C29	.02 mfd. 400v. paper
C30	.25 mfd. 400v. paper
C31	.01 mfd. 500v. paper
C32	.0004 mfd. mica
	d. 400v. paper
	fd. 400v. paper
	fd. 450v. } triple
	fd. 450v. } electrolytic
	fd. 25v. electrolytic
	047 mfd. 400v. paper
	9 mmfd. ceramic
R1	390 ohm ½ watt carbon
R2	100,000 ohm ½ watt carbon
R3	220 ohm ½ watt carbon
R4	47,000 ohm ½ watt carbon
R5	30,000 ohm ½ watt carbon
R6	47,000 ohm ½ watt carbon
R7	25,000 ohm ½ watt carbon
R8	390 ohm ½ watt carbon
R9	100,000 ohm ½ watt carbon
R10	47,000 ohm ½ watt carbon diode filter
R11	47,000 ohm ½ watt carbon
R12	300,000 ohm 1/3 watt carbon
R13	2,200 ohm ½ watt carbon
R14	2.0 megohm volume control with tap and switch
R15	25,000 ohm ½ watt carbon
R16	1 megohm ½ watt carbon
R17	470,000 ohm ½ watt carbon
R18	2.2 megohm ½ watt carbon
R19	250,000 ohm ½ watt carbon
R20	2.2 megohm ½ watt carbon
R21	100,000 ohm ½ watt carbon
R22	47,000 ohm ½ watt carbon
R23	.5 megohm tone control
R24	470,000 ohm ½ watt carbon
R25	25,000 ohm ½ watt carbon
R26	2,200 ohm 3 watt carbon
R27	6,000 ohm ½ watt carbon
R28	150 ohm 1 watt carbon
R29	500 ohm 4 watt wire-wound
R30	27 ohm ½ watt carbon
R31	390 ohm ½ watt carbon
R32	27 ohm ½ watt carbon
R33	25,000 ohm ½ watt carbon (672 only)

* NOTE.—For model 643 delete R33, pickup, gram. motor and switch.

The Editor's Opinion

THE GRUNDIG "REPORTER" TAPE RECORDER

One of the most recent recorders to have appeared on the British market is the Grundig, which seems to have built itself a very good reputation in a very short time. It was with great interest, therefore, that we received a sample for test. The machine is of German origin, but is made in England by Grundig (Great Britain) Ltd., and marketed here by the New



Zealand agents, Direct Import Ltd., Hastings, and through their distributors, Messrs. Turnbull & Jones Ltd., from whom our sample came. Only a very brief spell at the controls served to indicate that here was an instrument that would stand up to a quite searching examination of its performance, and such turned out to be the case. The Grundig is of very advanced [illegible] mechanical and electrical design, and embodies a number of refinements of the kind which appeal not only to the technically minded, but, what is more important, to the non-technical user, who is interested only in performance and not in how it is obtained.

THE MAIN FEATURES

The "Reporter" is a portable instrument, operating at either 7½ or 3¾ in. per second, and is arranged for half-track working. It is provided with a high-quality condenser microphone, and has a mechanical and electrical performance which makes it suitable for the most exacting applications. It is fitted with a cueing scale, and with an instantaneous stopping device, which makes it perfectly suitable for use as an office dictating machine—a feature we have not observed in any other recorder which is capable of high-fidelity music reproduction!

Perhaps the first thing to strike one about the specification is that only one motor is used. Hitherto, most tape recorders with any pretensions towards quality have used two or three motors, but the design of the Grundig is such that its really excellent results are obtained by the use of only one. It is no ordinary motor, however, for, although electrically it is a conventional split-phase induction motor, it reverses the usual order of things by having the stator windings inside, with the rotating cage outside them. The motor shaft is ground down to the correct diameter for it to act directly as the driving capstan, so that the rotor and a rubber-tired pressure wheel are the only moving parts apart from the tape spools.

The reels are driven each by its own magnetic clutch, whose lower portion rotates continuously, driven by a plastic endless belt which bears on a pulley attached to the motor shaft. It will be seen from this description that it would be virtually impossible to design a transport system with fewer moving parts, and in our opinion it is this simplicity, combined with the use of a small-diameter capstan and a high-inertia motor, which gives the recorder its remarkably high constancy of speed. The use of magnetic clutches has another important bearing on the design of the machine as a whole. They enable the designer to do away altogether with complex mechanical methods of interlocking the various functions such as fast rewind and forward speeds, since all that has to be done can be accomplished electrically, by means of switching current to the solenoids of the magnetic clutches and to the motor windings. What could be simpler and less conducive of faults, for example, than the method used for changing from 7½ to 3¾ in./sec.? It consists in nothing more than switching a lower supply voltage to the motor, whose inertia is such as to give satisfactory speed constancy under these conditions. A glance at the circuit shows that the switching arrangements are quite formidable in their scope, but the reliability of modern switches is such that exchanging mechanical complexity for electrical is very good practice.

One of the most pleasing features of the Grundig is the attention which has obviously been paid to ease of operation. Under this heading we would also include such points as the difficulty of producing accidental erasure, and the general difficulty of "doing the wrong thing." For each operation that may be performed, there is a separate push-button, which operates a multi-point switch, setting up all circuits automatically. On the "Record" positions, for example, pressing the button starts the motor, routes the signal appropriately, and lights the magic-eye level indicator. The tape, however, does not start to move. In this position, it is possible to set the level by means of the numbered volume control, because the circuits are all operating. Then, when the "Start" button is depressed, the magnetic clutches are operated, and recording commences. All operations are stopped by the one "stop" press switch, which is in the form of a long bar rather than a button, enabling it to be selected without even looking for it. The "stop" bar releases whatever bars have been pressed, so that it will become necessary to set up the next operation by pressing the appropriate selector button and then the "start" button. "Fast Rewind" and "Fast Forward" do not require the use of the "start" button. It is noteworthy that there is no separate position called "Erase," the only way in which erasure can be done being by setting up one of the "Record" buttons and then pressing the "start" button. This makes an almost fool-proof check against accidental erasure. The use of a separate "Start" button allows the high-inertia motor to come up to speed before the tape starts to move through the heads, and also is a substantial check on the accidental wrong opera-

tion, merely because two separate things must be done before anything happens.

Most people who use a tape recorder want to use it in conjunction with a radio receiver or amplifier, and the Grundig has been arranged to make this kind of operation very simple. It is possible to take the output of the recorder, on playback, to feed into an external amplifier, with or without muting the built-in speaker. The output of a radio set can be fed in for recording without silencing the set's own speaker, and without having the built-in speaker operating. A push-button even exists for using the tone-compensating circuits of the recorder as an equalizer, without the mechanism functioning. And, finally, there is the instantaneous "Stop" button. This can be operated by hand, by anyone dictating into the recorder, and works in the following way. Unlike the main "Stop" bar, this one does not affect the setting of the mechanism. It merely stops the tape almost instantaneously. It has no catch, so that when it is released, the mechanism starts again, equally suddenly. Thus, it is possible while dictating to stop the tape temporarily while searching for a phrase, starting up again as soon as one has thought out what is next to be said. This prevents the record of the dictation from having long pauses in it, which are most disconcerting to anyone transcribing from the record. For transcribing, this instantaneous stop-and-start feature can be operated by a foot-switch, which can be had as an attachment, so that a typist can read off a phrase, stop the machine while typing, and start it up again as soon as she is ready. Thus no time is lost in continually turning back because the dictation may be too fast to follow continuously. So quickly does the stopping take place, that one can operate it between syllables of a word, and not miss one on re-starting!

PERFORMANCE

Readers will be just as interested in the actual performance of the recorder as in the things it will do, and at the outset we would like to say that the fidelity is excellent. This recorder is fully capable of recording music with sufficient fidelity to satisfy all but the super-critical. Perhaps its best feature is the lack of "wow." We purposely refrained from recording tone from an oscillator until we had tried some music, recorded from a high-quality pick-up, using a very good turnatable which is quite free from audible "wow." The results were very pleasing indeed. One piece of orchestral music which we have found particularly susceptible to speed variation came through without a trace of "wow" or flutter, as did that most difficult instrument of all, the piano. Moreover, the quality, as judged by feeding the output of the recorder into a high-fidelity amplifier, was wellnigh indistinguishable from that of the original record, played through the same amplifier.

The specification states that the frequency response on 7½ in./sec. should be within 3 db. from 60 to 10,000 c/sec., and a check revealed that, on the sample, this was not quite achieved, the figures obtained showing that the playback response was within 3 db. from 50 to 8,000 c/sec. However, the sample model was one which was by no means new. It had seen a great deal of use over an extended period, and it seems likely that the high-frequency pre-emphasis control,

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which is a pre-set, inside the cabinet, needed some slight adjustment. Most recorders of this kind have no provision for adjustment of the frequency response, which means that, as the heads wear, it is impossible to compensate the response except by replacing the heads. We have no doubt that the full range up to 10 kc/sec. would be readily available in this particular case simply by adjusting the pre-set control.

The recording of pure tone is, of course, the most stringent possible test for speed constancy. Since the capstan on this instrument is a high-speed one, "wow" is not likely to show up as a slow variation in pitch, but rather as a fairly fast flutter, and such was found to be the case. Unfortunately, we are not able to report that no trace of "wow" was found, but such speed variation as did exist was so slight that it could be audibly observed only by recording and playing back a tone from the audio oscillator. At all frequencies below 1,000 c/sec., the slight flutter was quite imperceptible, and even when it could be heard, which was with 1,000 c/sec. and higher frequencies, one had to listen very intently to hear it. As was observed earlier, we purposely did not record a tone until we had attempted to observe speed variation by listening to recordings of music, and this it was quite impossible to do, indicating what the tone recording confirmed, a remarkable degree of speed stability. If we have enlarged somewhat on this aspect of the performance, it is because the question of speed variation and "wow" is one upon which so many tape recorders fall down utterly. Low waveform distortion and wide frequency response are quite useless unless the speed variation is very, very small. (Continued on page 48.)

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* * *

TELE-COMMUNICATIONS LTD.

In Wellington, moves through business expansion seem to be the order of the day. Now we find that Tele-Communications Ltd., who specialize in transformer manufacture, besides retaining their former premises, are also occupying more spacious quarters in Lower Tory Street, where they will be pleased to welcome all clients.

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* * *

GIFTS TO SEDDON MEMORIAL TECHNICAL COLLEGE

Mr. R. Waddell, of the Seddon Memorial Technical College, Auckland, gratefully acknowledges the generous gifts made to the college by Philips Electrical Industries of N.Z. Ltd. These comprise a bound volume of Philips Electronic Application Bulletins and a small demonstration unit which, in effect, is the power supply and C.R.T. of an oscilloscope. The latter has proved particularly useful in teaching the uses of oscilloscopes to students.

In addition, they have also presented the college with a Philips TV receiver, type TG.1437N, with a 17-inch screen, which will be of great assistance to students taking the TV course.

* * *

WISEMAN ELECTRIC CO. LTD.

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RAPID GROWTH

A contemporary English journal reminds us of the astonishing growth of wireless and its many offshoots in just over 50 years. At the commencement of the century, it was considered that wonderful progress had been made when messages, in rather slow Morse, could be sent over very short distances. Less than twenty years later, long-wave communication systems spanned the world, communications over moderate distances were

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established on the medium waves, and the coming of the valve made wireless telephony practicable. The latter gave birth to broadcasting.

While text-books held that long distances demanded long waves and high-power transmitters, amateurs claimed satisfactory communications, using their short-wave equipment, with fellow amateurs in Europe, America, Africa, and Australasia. That led to a revolution in long-distance communications.

Meantime, another promising youngster had just been born—television!

Yet another branch, radar, was relatively little known by the general public until it had achieved a sturdy growth, using first the metre and then the centimetre waves.

Unattended and entirely automatic radio links led to high power, unattended broadcasting stations—and so it goes on. Progress is so fast that we wonder if the complete story will ever be written.

* * *

TV AT THE 1937 CORONATION

We all know of the magnificent part played by television at the Coronation of our gracious Queen Elizabeth in June last. How many of us know that it played an equally epoch-making part in 1937, when the very first outside television broadcast programme was that of the Coronation procession!

For this great event the B.B.C.'s outside-broadcast camera unit came into operation only just in the nick of time, but, of course, there were no tele-recording or telefilming facilities at the B.B.C. in those days. However, this broadcast was filmed direct from the screen by one enthusiast, none other than Mr. J. E. Davis, Manager of the Technical Information and Publicity Division of the Marconi International Marine Communication Co. Ltd., of Chelmsford. He has long been a cine-camera enthusiast, and has also owned TV receivers since the early days of viewing. This film is thus the result of the happy combination of these two hobbies.

Using a 16 mm. Moviekon Camera at F1.5, he found synchronization difficult, as the camera had no 25-frame speed to match the 50-frame speed of the TV screen picture, although the amount of exposure would have been insufficient. However, a compromise was effected by the use of 12 frame-speed setting on the camera, in the hope that it would run into approximate synchronization as well as giving better exposure. The results were quite good, though Mr. Davis feels that, with these synchronization and exposure difficulties, the film does not do full justice to the quality of 1937 TV, besides which, he recalls that the dull and showery weather must have been a handicap to the TV cameras.

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		PT.29.M.	

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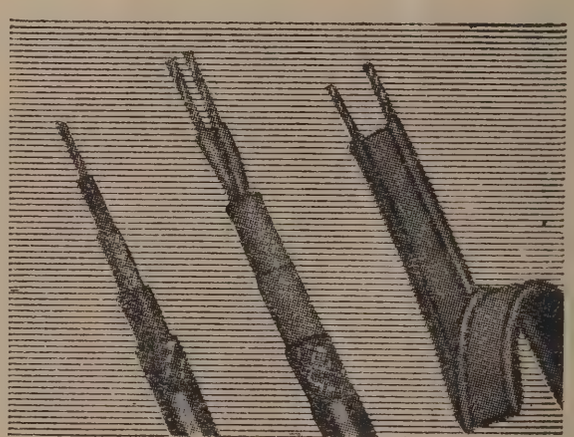
BA.24.PSM. BA.3.PSM.
K.12.SM.



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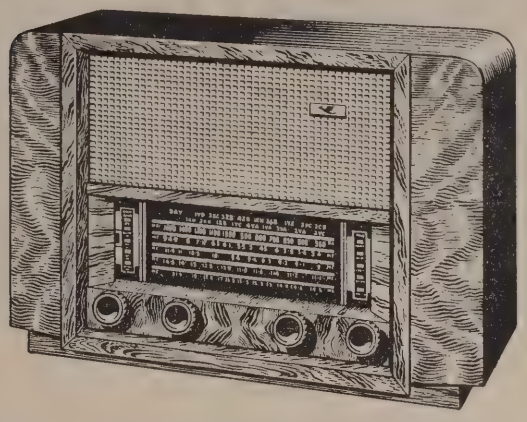
THE NEW "ULTIMATE" 6-VALVE BROADCAST MANTEL



The new "Ultimate" illustrated here has an exceptional performance. It has all that would normally be asked for, plus refinements that place it in a class of its own.

The "Ultimate" 6-valve broadcast is a full 6-valve radio with a highly selective R.F. stage and powerful audio circuit. It has been engineered to give greater listening pleasure, and its cabinet of figured and straight-grained walnut veneer give it a smart appearance with excellent tonal response.

Additional features include a heavy-duty power transformer, constantly variable tone control, 6-9 elliptical speaker, gramophone switch, and input sockets, plus extension speaker terminals.

The large floodlit dial, with its colourful engraving and open calibration provides easy and accurate station tuning. The output stage is scientifically balanced for maximum clarity on speech and mellow musical response.

The new "Ultimate" 6-valve broadcast receiver is a de luxe job, and for those who want a fine-quality versatile receiver, it gives extraordinary value at £35 19s. 6d. retail.

Orders are heavy for the first run of these, so early delivery in 1954 can be given only to those who order immediately.

Cabinet dimensions are: 21¾ in. long; 14⅛ in. high; 9 in. deep. Price, retail, £35 19s. 6d.

EDINBURGH

Electric Radiator

ANOTHER PANAMA PRODUCT

★ Two 10-inch bars

★ Individual Switching

★ Red Glow Visible at Base

★ Louvres for Heat Dissipation

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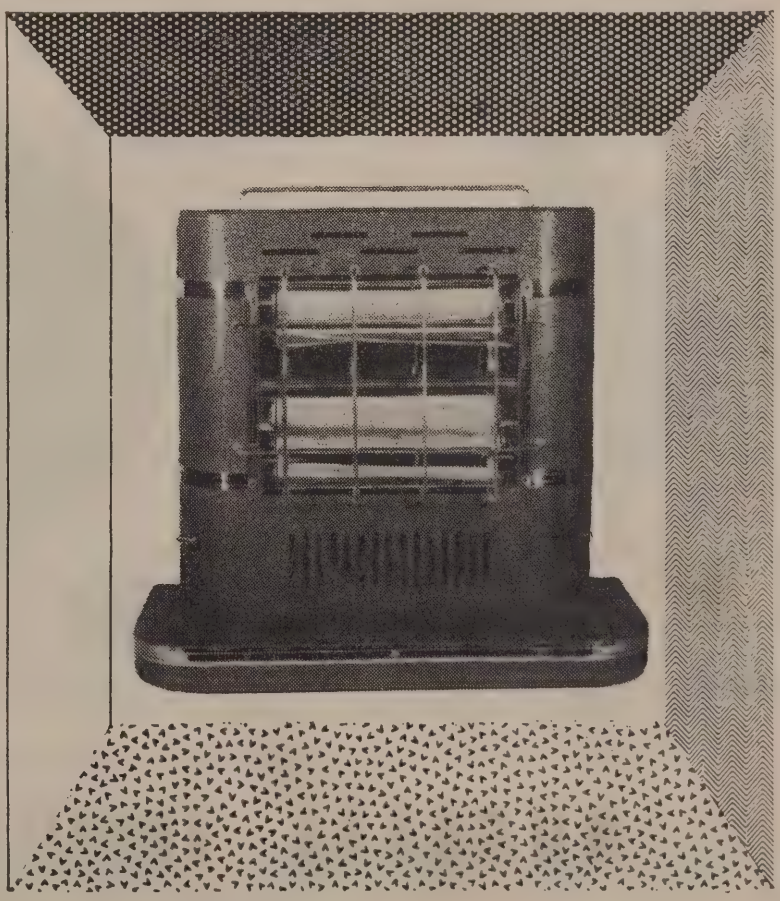

CORY-WRIGHT and SALMON LTD. WELLINGTON

Collaro

3RC531
3RC532

3-SPEED AUTOMATIC RECORD-CHANGERS

INTRODUCING

The new "Studio"
High Fidelity
Turnover
Crystal Pick-Up

Three-speed Models feature an entirely new positive and foolproof change-speed mechanism.

The Collaro 3RC53 *series incorporates an entirely new type of simple mechanism designed to give reliable and foolproof constant record-changing together with high-fidelity reproducing from the new Studio Turnover Crystal Pick-up. The new Collaro* 53 *record-changers play all types of records* 33 *r.p.m.,* 45 *r.p.m.,* 78 *r.p.m. in* 7 in., 10 in., *and* 12 in. *discs, and at* £14 10s. *bring record-changing facilities within reach of all. Finished in pale cream, with pick-up to match, the new Collaro* 53 *changers set a new standard for Automatic Record-changer units.*

Sole New Zealand Distributors:

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AN ENLARGED PICK-UP HEAD

In the above photograph, Mr. Walter Christianson, of WALCHRIS of Sweden, is seen holding a large Supersound head and arm made in transparent acetate plastic. This model head, which Messrs. W. S. Green & Co. Ltd. have arranged to be brought to New Zealand is ten times linear enlargement. All details are exactly reproduced, and show the working of the three-pole design. The armature may be seen operating when the sapphire is moved by hand. Cutaway parts of the assembly enable the operation to be shown, while the head can be opened by a hinged door.

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ELECTRIC BED SHEETS
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Tape rules are fine for dressmakers; and we have noticed that surveyors, hop-step-and-jump judges, and well-diggers use them, too. But when it comes to tiddly little screws and such-like pieces of fine production, you want real accuracy. If *you* have a manufacturing problem—say 50,000 component parts machinable from bar stock—each one exactly the same as t'other—get in touch with us and we'll get our micrometers and automatic lathes at the ready.

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Television Round the World

SWITZERLAND ORDERS TV O.B. UNIT

Football has its fans the world over, and so that the European football championships can be televised from Berne in June, 1954, the Swiss broadcasting authorities (P.T.T.) have ordered a complete television outside broadcasting vehicle from Marconi's Wireless Telegraph Co. Ltd.

Not only will the programme be televised over the small experimental station at Zurich, but also to viewers on a system linking Italy, Germany, France, and possibly the Netherlands, so that each country can follow the fate of its respective teams in the championships.

With the Zurich station as the first stage, this television O.B. unit is the second stage in the Swiss authorities' plans to provide the country with television. The unit will contain three camera channels—i.e., three Marconi image orthicon cameras with their appropriate controls, mixers, and sound-mixing equipment. Though the interior of the vehicle will be so arranged that there is a maximum of space and comfort for the operators, all the equipment will be entirely mobile, and one "zoom" lens will be provided for use with any one of the cameras.

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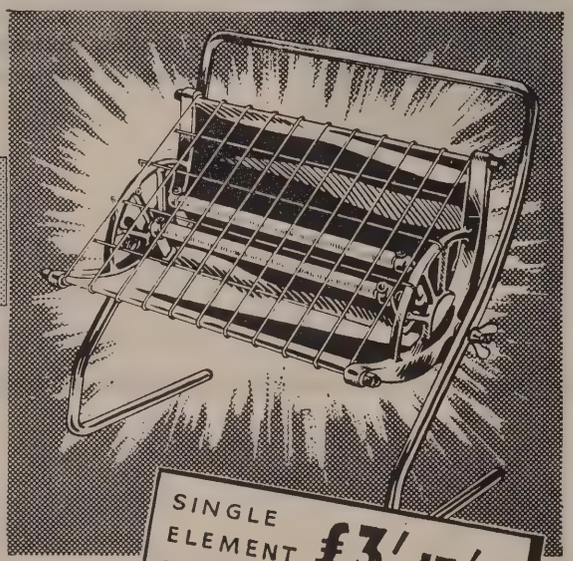
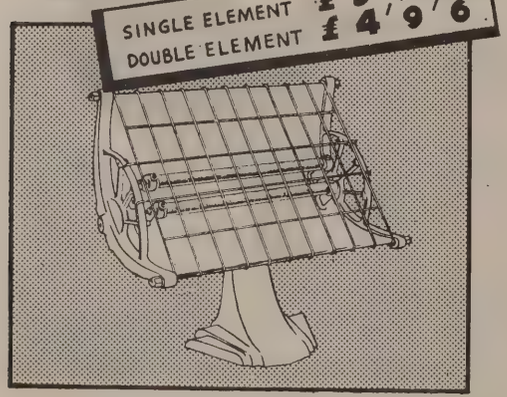
Beauty with SAFETY



Note the guard that covers the elements — it's a vital *safety* measure to prevent children or clothing from touching the red hot elements.

Poweray ELECTRICAL APPLIANCES



The Electric Radiator you can trust!

Apart from being a *SAFETY* Radiator, the "Poweray" has a beauty of design and appearance that will enhance any room. Finished in chrome, with adjustable heat reflectors. *GUARANTEED*, 2 years (Elements one year). All double element models have switch to turn on one or both elements. For safety's sake buy a "Poweray" with the Safety Guard.

Poweray ELECTRICAL APPLIANCES

ELECTRIC RADIATORS WITH THE SAFETY GUARD

N.Z. Agents: C. & A. ODLIN TIMBER & HARDWARE CO. LTD., WELLINGTON.

PYE INDUSTRIAL EQUIPMENT USED FOR EDUCATIONAL PURPOSES

The opening of the National College of Rubber Technology in London recently provided the opportunity for the demonstration of a novel new method of teaching students, using Pye industrial television equipment. After the installation of the industrial camera in the rubber shop on the ground floor, the audience of 180 viewed pictures on a Pye 27-inch monitor installed in the lecture theatre. Details of the processes and machinery which normally could be seen by only four or five students at a time were televised from the rubber shop to the audience in the lecture theatre, and questions asked there were answered by means of a talk-back system, the answers being illustrated by demonstrators in the rubber shop.

In addition to the main rubber shop, all the main laboratories at the college have been wired for television.

The entire equipment for the generation and control of the television image is contained within a single small camera case. Only two connections are necessary—viz., mains input and either low-level video output or an R.F. output, tunable over the normal B.B.C. channels.

Normally, the complete equipment, which costs less than £1,400, comprises a camera with a 1 in. focal-length lens, a camera pedestal, and a 14-inch monitor, complete with stand.

Vital Links in World Communications—The Story of the Submarine Cable

By JOHN GRINDROD

Still vital, despite radio developments, as the means by which most of the world's communications are transmitted, the vast network of submarine cables which lace together the continents of the world owes much to United Kingdom enterprise and engineering skill.

It was in 1850 that John W. and Jacob Brett managed to lay the first cable across the English Channel. Though it broke down after only a few hours, it was followed a year later by another more successful attempt, and this gave a great impetus to other submarine cable projects. Some of these were successful; others were costly failures. The latter were due mainly to lack of experience in the design and manufacture of cables which would withstand water penetration at great pressure, chafing, and the action of biological enemies; or to faulty technique in handling and laying.

THE FIRST TRANSATLANTIC CABLE

Bitter disappointment also attended the first attempts to lay transatlantic submarine cables. Laid in 1858, and evoking great enthusiasm on both sides of the Atlantic, the first Britain-to-America submarine cable was doomed to only a brief existence. Six years later, though, a new company, the Telegraph Construction and Maintenance Company, was formed in Britain and, in collaboration with Mr. Cyrus Field, an enterprising American, manufactured a new type cable. Using the famous cable ship *Great Eastern,* the company placed two cables across the Atlantic—although not until after further initial disappointments.

The ultimate success of this venture encouraged development toward the east. Three companies, later to be merged into the Eastern Telegraph Company, were formed in Britain, and the first long-distance link in this eastern chain was opened for public service in 1870, when telegrams were accepted in London for transmission by submarine cable to India and intermediate countries. Outstanding in the establishment of this undertaking was John Pender, a Member of Parliament, who had already contributed much toward the Atlantic cables. Three years later the service was extended to Australasia.

While United Kingdom engineers were thus crossing the globe with their subamrine cables, other countries were busy in this field, too. For instance, the Great Northern Telegraph Company was formed to establish communications with Shanghai via the Baltic Sea and Russian landlines; a Spanish company linked Spain with Britain; South and Central American companies were running underwater cables along their coasts, and the number of Atlantic cables was being multiplied.

The most recent of the 22 existing Atlantic cables to be laid were those put down in 1926 and 1928 by the Telegraph Construction and Maintenance Company for the Western Union Telegraph Company. The 1926 cable still has greater traffic-carrying capacity than any other cable of similar length in the world.

GOVERNMENTAL ENCOURAGEMENT

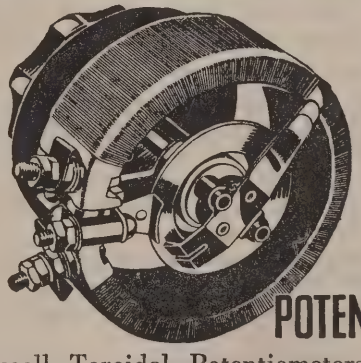
Another landmark in the history of the submarine cable was the formation of the Paicfic Cable Board, which, representing the Commonwealth Governments, laid the longest continuous cable in the world from Vancouver Island to Brisbane and New Zealand. With the trans-Canadian line this made possible an "all red" route linking Britain, Canada, Australia, and New Zealand.

Yet another cable route to Australia was established by the extension of the London-South Africa cable to Perth and then to Adelaide. Thus three submarine cable services linked with Australia, and this position obtained till 1927, when the direct beam radio service was inaugurated.

The development of radio and its competition with the cable interests, together with the competition between the Eastern Telegraph Group and the Pacific Cable Board, led to the Imperial Wireless and Cable Conference of 1928. Out of this came the merging of interests into Imperial and International Communications Ltd., later to be known as Cable and Wireless Ltd., with a total staff of 13,000 and some 253 cable and radio stations throughout the world, involving some 164,000 miles of submarine cable. This represented more than half the total mileage of the whole world. Also belonging to the company were 13 cable ships.

Under one control, cables and radio were used to complement each other. While radio provided the long-distance telephone facilities and catered for picture and

CRESSALL



TOROIDAL WOUND POTENTIOMETERS

Cressall Toroidal Potentiometers are wound on a heat-resisting ceramic former and are produced in two types: R50 (50 watts) and R100 (100 watts), and also 4 and 6-watt units, both line and insulated spindle. The larger types can be supplied as double or triple-ganged units with simultaneous drive. "Off" position types and slow-motion drive also available. Wide range of Toroidal Wire Wound Potentiometers held in stock; also resistance grids and sliding resistances. Made by the CRESSALL Manufacturing Co., Ltd., England.

Sole New Zealand Agents:

Bradley's Electrical Co., Ltd.

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And at 62A COOK STREET, AUCKLAND

facsimile transmission, the cable was able to provide uninterrupted telegram service under all conditions.

AND NATIONALIZATION

Following the difficult war period, with its greatly increased traffic, its loss of stations and cable routes and its opening up of new stations and cables, came further changes in organization, when Commonwealth countries nationalized their services. The United Kingdom communications assets of Cables and Wireless Ltd., were integrated with those of the Post Office, though the great network of cables is still operated by the company.

The failure of early submarine cables focused attention on design, and this was developed rapidly by Britain's engineers in the nineteenth century until a conventional type gutta-percha cable was formulated. The only principle changes that have taken place in the cable itself during this century have been in the making of inductively-loaded cables to improve transmission, and the use of the plastic polyethylene instead of gutta-percha, especially for submarine telephony and high-speed telegraphy. At the same time, methods of automatically regenerating signals at intermediate points along the cable have been developed.

The trend of development has been, and still is, toward the incorporation of a greater number of comunication circuits, both telephone and telegraph, within the cable. Also the range, hitherto limited, over which telephone communications can be transmitted by cable, is being extended. In this and in other technical fields Britain's engineers are still well to the fore.

Both the dielectric and the magnetic amplifier of the simple type of Fig. 1 act as frequency doublers when operated at the zero bias point because either a positive-going or a negative-going signal produces an increase in output. The signals are 18 degrees out of phase, however, since at zero bias the output of the simple saturable reactor is minimum while that of the dielectric is maximum. The self-saturated magnetic amplifier more nearly resembles the vacuum tube in phase relationships.

The dielectric amplifier, the transistor, and the magnetic amplifier have the advantage of requiring no filament power or warm-up time as with the vacuum tube type. The dielectric and magnetic amplifiers have the additional advantage of requiring no precision constructional techniques such as are needed in fabricating vacuum tubes and transistors. Both are characterized by almost infinite life and ruggedness. The magnetic amplifier is also considerably better than the dielectric and transistor amplifier from the standpoint of temperature dependence.

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ARCOLECTRIC will make it
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WELLINGTON "R. & E." TELEVISION COURSE

We have pleasure in announcing that the second "R. & E." Television Course in Wellington will take place in February, 1954. This course is being provided to cater for those who were unable to attend the original one held in September last owing to the restrictions imposed by space limitations. The material content of the lectures and the demonstration equipment will be the same as used in the first course, and all further details, including a full syllabus, together with a list of suggested study books, will be supplied on request.

This second course will be held in the lecture room, Air Department Building, Bunny Street, Wellington, at 7.30 p.m. on the following dates:—

Monday, February 8, 1954.
Tuesday, February 9, 1954.
Wednesday, February 10, 1954.
Monday, February 15, 1954.
Tuesday, February 16, 1954.
Wednesday, February 17, 1954.
Monday, February 22, 1954.
Tuesday, February 23, 1954.
Thursday, February 25, 1954.
Monday, March 1, 1954.

All intending students are requested to register as soon as possible by completing the attached form and forwarding it, together with the fee of £4 4s., to Radio and Electronics (N.Z.) Ltd., P.O. Box 8022, Wellington. Please inscribe the words "TV Course" on the bottom left-hand corner of all such communications.

Radio and Electronics (N.Z.), Ltd.,
P.O. Box 8022,
Wellington.

Please accept my registration fee of £4 4s. for the "Radio and Electronics" TV Course to be held in Wellington from February 8 to March 1 inclusive, and forward all further information to me at the following address:—

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RADIO CLASSES

For Operators, Engineers, Servicemen, commence on 1st February, 1954. Enrolments received now.

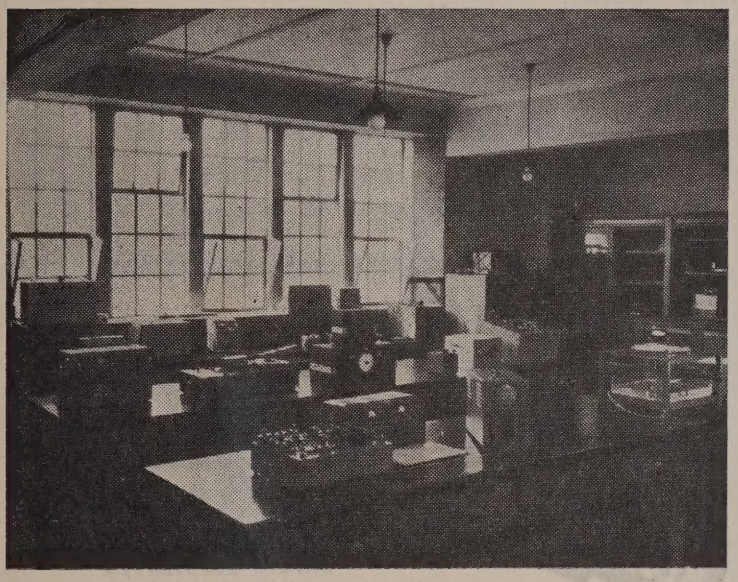
NEW ZEALAND RADIO COLLEGE
26 HELLABY'S BUILDING - AUCKLAND, C.1

Electronics at V.U.C.

Some little time ago now, members of the radio industry in Wellington were privileged to visit the Physics Department at Victoria University College in order to gain some idea of the considerable amount of work being done there in electronics. These and other short paragraphs which are to follow illustrate some of the important work being done there in training physicists in this work. Needless to say, much of the work is at post-graduate level, and is being performed by the staff or by students writing theses for the M.Sc. degree.

RADIOPHYSICS COURSE

(Prof. G. A. Peddie)



General view of one of the Radiophysics Laboratories at Victoria University College. Balanced mixer, low-noise figure I.F. pre-amplifier, and signal generator for use at 25 cms. Equipment used in investigating noise radiation from gaseous discharge tubes.

The radiophysics course, with associated laboratory work, offers a training in theoretical and practical radio and electronics of a standard comparable with that demanded for A.M.I.E.E. Students undertaking the course have already had at least two years' training in university physics, together with a reasonable mathematical background.

An attempt is made in the lectures to maintain a balance between the theoretical performance and the practical operation of electronic devices and circuits and laboratory experiments, often specially devised, serve to illustrate and extend some of the lecture material.

The laboratory course is designed to cover the following aspects of radio work:—

(1) Fundamental measuring techniques;
(2) Illustration of basic methods of measuring circuit components, etc., at radio frequencies;
(3) Performance of typical commercial equipment;
(4) Accurate measurements using laboratory components, as distinct from commercially built-up equipment;
(5) Practical performance of electronic circuits;
(6) Experience in the design and wiring-up of typical electronic equipment;
(7) Early introduction to new techniques and devices;
(8) Presentation of experimental results.

Due to the increasing use of electronic devices in physics, engineering, and industry, it has become common practice for a student proceeding to the Honours course in physics to cover the radiophysics course, even though the student's interest may be fundamentally in a topic such as nuclear physics.

THE WILSON CLOUD CHAMBER

(N. V. Ryder)

Any charged atomic particle leaves a trail of charged ions as it passes through a gas. The Wilson Expansion Chamber produces condensation on these ions and so makes visible the paths of the particles. (To obtain sharp tracks, the expansion must occur within about 15 milliseconds of the passage of the particle.)

Geiger-Muller Counters and Coincidence Circuits are used to trigger the chamber when a suitable Cosmic Ray event occurs. The chamber expansion valve is operated by a flip-flop circuit comprising an 807 and an EF50.

Between expansions a cleaning process of several slow compressions and expansions is carried out. This process is controlled by a number of relays and "Uniselector" switches, the overall cycling rate being controlled by an 85A1 pulsing circuit.

On automatic operation, the control circuit selects a cosmic ray event, expands the chamber, photo-

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graphs the track stereoscopically using electronic flash illumination, and then prepares the chamber for the next event. Mechanical counters record the number of events and a clock records the total sensitive time.

Seven-valve Radiogram

(Continued from page 7.)

and for the switching of the tertiary winding of the second I.F. transformer.

POWER SUPPLY

The power supply is just the usual style of thing, the requirements of the set being 250 volts at 100 ma. On the diagram, a 280-volt-a-side transformer is shown, but if one with this secondary voltage is not available, it will be necessary to use one with a voltage of 310-a-side. If this is done, the output voltage will be rather high, and in this case the dotted resistor should be inserted. Its value should be 1,000 ohms.

In some ways this is quite an unusual receiver, but in our opinion it is one well worth building, for it should give pleasure to the whole household, at a very moderate outlay, considering the facilities provided.

Philips Experimenter

(Continued from page 33.)

does not present many difficulties. In Part 2 of this article, we will have something to say about the various kinds of NTC resistor, and will present graphs showing their actual performance.

Subminiature Assemblies

(Continued from page 30.)

There will be heating due to chemical action. Allow to cool slowly to room temperature. After eight hours, the mould may be removed (see Fig. 4D) if the mass has hardened sufficiently. An alternative procedure for fast hardening and curing is, after the mass has cooled to room temperature, to heat it for 30 minutes in an oven at 160° to 225° F.

The potted block is transparent and colourless, and will reveal the imbedded components and wiring.

CLASSIFIED ADVERTISEMENTS

WANTED—Communications Receiver, good condition (American type preferred); range 550 k/cs. to 30 m/cs.; variable selectivity; crystal phasing; A.F.-R.F. gain, etc. Write, F. R. Haworth, 130 Perry Street, Masterton.

THE GRUNDIG "REPORTER" TAPE RECORDER

(Continued from page 38.)

CONCLUSION

In the Grundig "Reporter" we have a tape recorder which is versatile, remarkably easy and convenient to use, and which is capable of reproduced quality surpassing that of all but specially designed high-fidelity radio receivers and that of most gramophone records. The hum and noise level are very low, giving it an excellent dynamic range; it is eminently suitable for all musical applications, and yet is arranged to be as useful as a machine designed solely for office work. Altogether, a very pleasant machine to handle, and one which on a performance-for-price basis will be difficult to improve upon.

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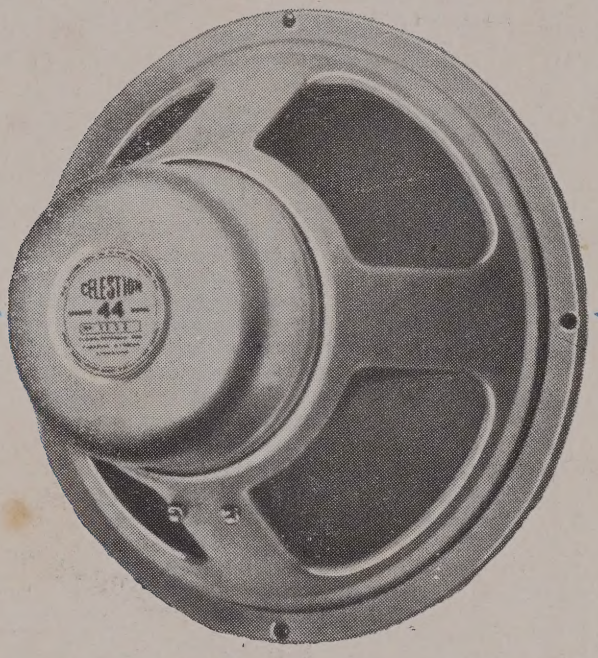

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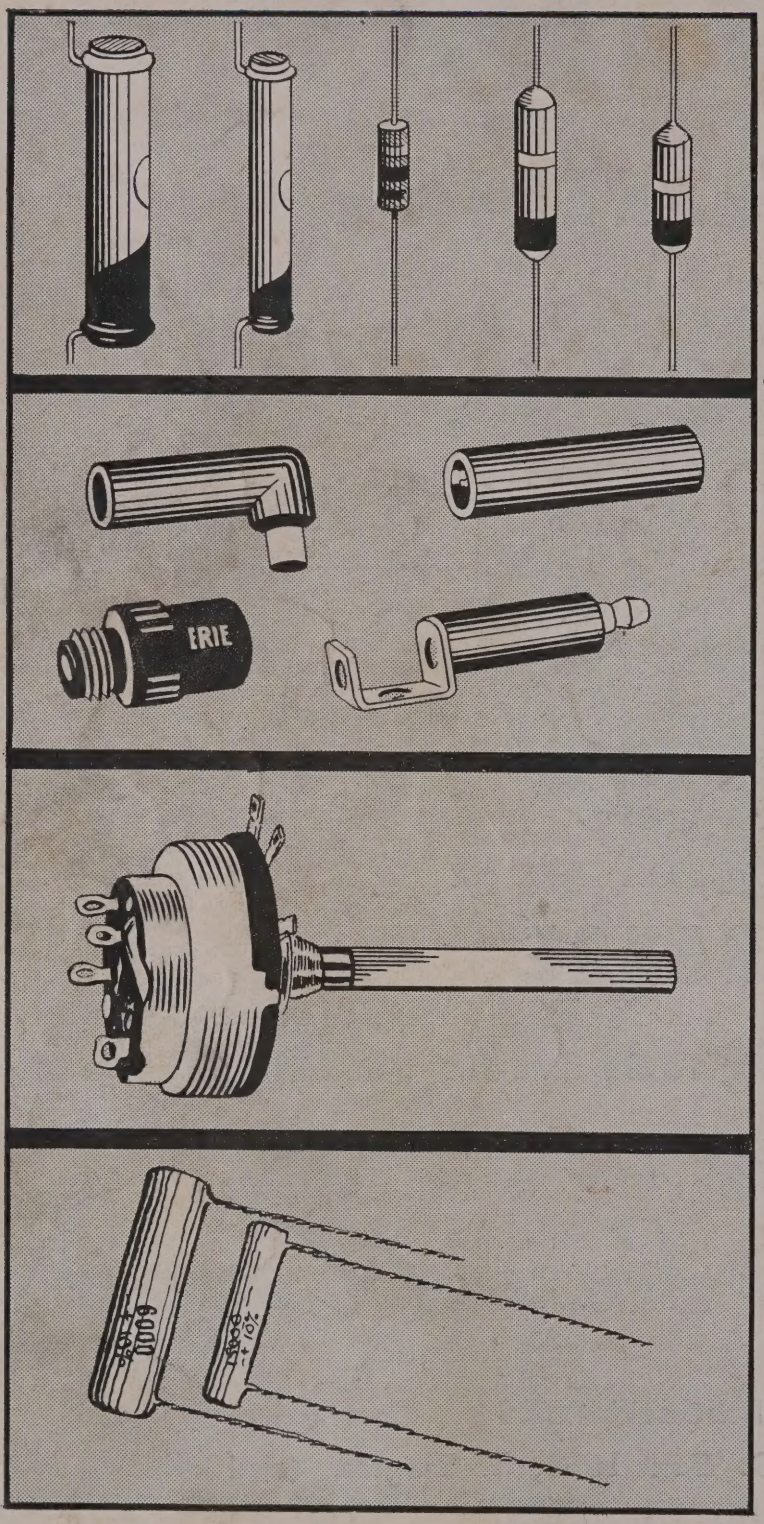

CARBON RESISTORS

Erie Resistors are the finest offering on the New Zealand market. Constant research has not only improved their electrical characteristics, but has resulted in the development of new, smaller units and insulated types that meet the urgent demand for efficient performance in restricted space under severe operating conditions.

SUPPRESSORS

Erie Suppressor Resistors are designed for the suppression of high-tension interference caused by the ignition system of internal-combustion engines without detracting from the performance of the engine. Available in four different types sufficiently diverse to fit any known make of car.

POTENTIOMETERS

Erie Potentiometers are of the carbon-track type and embody a carbon-sprayed bakelite element with a maximum overall dissipation of one watt, and are available in values from 2,000 ohms to 2 megohms inclusive, either with or without switches, which are of the S.P. Single Throw and D.P. Single Throw types only.

SILICONE FINISH WIRE-WOUND RESISTORS

Erie Silicone-finish Wire-wound Resistors are wound on a high-grade ceramic former which will withstand considerable thermal shock without disintegration. Windings are spot-welded to flexible copper nickel or nickel chrome wires brought out in the form of pigtails tinned with hot solder or connected to nickel silver bands according to individual preference. A wide range of ratings is available from stock in the more commonly used resistance valves. Quotations can be given for non-stock sizes.

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